PROCEEDINGS

OF THE

ASSOCIATION OF MUNICIPAL AND SANITARY ENGINEERS AND SURVEYORS.

VOLUME III.—1875-6.

EDITED BY

LEWIS ANGELL,

M. INST. C.E., F.R.I.B.A.,

ASSOCIATE AND HON. FELLOW OF KING'S COLL., LOND.,

PAST PRESIDENT OF THE ASSOCIATION.

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ASSOCIATION OF MUNICIPAL AND SANITARY ENGINEERS AND SURVEYORS.

LIST OF OFFICERS, 1875–6.

COUNCIL.

President.

JAMES LEMON, Assoc. Inst. C.E., Southampton.

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HONORARY MEMBERS.

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MEMBERS.

ALLEN, T. T.	Town Surveyor, Stratford-on-Avon
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HALL, J. A.	Surveyor to the Local Board, Toxteth Park, Liverpool.
HALL, J. G.	City Surveyor, Canterbury.
HALL, M.	Surveyor to the Local Board, South Shields.
HARDIE, WM. Y.	Surveyor to the Local Board, Withington.
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Johnson, T. L., Assoc. Inst. C.E.	Borough Surveyor, Cardiff.
JONES, C., Assoc. Inst. C.E. (*Hon. Secretary.*)	Surveyor to the Local Board, Ealing.
Jones, J. M.	City Surveyor, Chester.
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Martin, J.	Surveyor to the Local Board, Radford, Notts.
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MORANT, A. W., Assoc. Inst. C.E. (*Vice-President.*)	Borough Surveyor, Leeds.
Morgan, W. B.	Surveyor to the Local Board, Weymouth.
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Newman, F.	Borough Surveyor, Ryde, Isle of Wight.
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NICHOLSON, W.	Sanitary Authority, Axbridge.
NOOT, W.	Surveyor to the Local Board, Tunbridge.
PALMER, J. E.	Surveyor to the Local Board, Malvern.
PARKER, J.	Borough Surveyor, Bridgewater.
PARRY, A.W., Assoc. Inst.C.E.	Borough Surveyor, Reading.
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PRITCHARD, E., Assoc. Inst. C.E. (*Vice-President.*)	Borough Surveyor, Warwick; *Hon. Secretary*, Midland District.
PROCTOR, J.	Borough Surveyor, Bolton.
PURNELL, E. J. .. .. .. (*Member of Council*)	City Surveyor, Coventry.
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RODGERS, S.	Town Surveyor, Wath-upon-Dearne, Yorkshire.
ROGERS, J. R.	Surveyor to the Local Board, Hornsey, London.
ROYLE, H.	Town Hall, Hulme, Manchester.
SANDOE, W. D.	
SARGENT, B.	Borough Surveyor, Newbury, Berks.
SHARMAN, E.	Surveyor to the Local Board, Wellingborough.
SHARP, J. Fox, Assoc. Inst. C.E.	Borough Surveyor, Hull.
SHUTTLEWORTH, F. H. ..	Surveyor to the Local Board, Littleborough.
SIDDONS, G.	Town Surveyor, Oundle, Northamptonshire.
SIMPSON, J. D.	Surveyor to the Local Board, Buxton.
SMITH, E. B.	Surveyor to the Local Board, Oswestry.
SMITH, G. F.	Surveyor to the Local Board, Milverton.
SMITH, F., Assoc. Inst. C.E.	Borough Surveyor, Blackburn.
SMITH, J. H.	Surveyor to the Local Board, Taunton.
SMITHURST, J. H.	Surveyor to the Local Board, Sowerby Bridge.
SPENCER, J. P.	Borough Surveyor, Tynemouth.
SPOND, J. W.	Town Surveyor. Alverstoke.
SPRINGALL, W. E.	Town Surveyor, Folkestone.
STANDING, J.	Surveyor to the Local Board, Garston, Liverpool.
STAYTON, G. H.	Borough Surveyor, Ryde.
STEPHENS, E. L. .. .. .. (*Member of Council.*)	Borough Surveyor, Leicester.
STEPHENSON, G. W.	Town Surveyor, Cambridge.
SUNDERLAND, T.	Borough Surveyor, Blackpool.
THOMPSON, G.	Borough Surveyor, Derby.
THOMS, G. E.	Borough Surveyor, Wolverhampton.
THORBURN, T. C. .. .. .. (*Member of Council.*)	Town Surveyor, Birkenhead.
THWAITES, C., Assoc. Inst. C.E.	City Surveyor, Norwich.
TILL, W. S. .. .. (*Member of Council.*)	Borough Surveyor, Birmingham.
TRAPP, S. C.	Surveyor to the Local Board, Prestwich, Lancashire.
TUDOR, E. C. B.	Surveyor to the Local Board, Goole, Yorkshire.

Valle, B. H.	Surveyor to the Local Board, Stow-on-the-Wold, Gloucester.
Vawser, R., M. Inst. C.E. .. (*Member of Council.*)	Borough Surveyor, Warrington; *Hon. Secretary*, Lancashire District.
Walker, H.	Surveyor to the Local Board, Basford, Notts.
Walker, T., Assoc. Inst. C.E.	Surveyor to the Local Board, Croydon.
Ware, C. E., Assoc. Inst. C.E.	City Surveyor, Exeter.
Waring, T., M. Inst. C.E. ..	Borough Surveyor, Cardiff.
Watson, G.	Surveyor to the Local Board, Crewe.
Wheeler, W. H., M. Inst. C.E.	Borough Surveyor, Boston.
White, W. H., Assoc. Inst. C.E.	City Surveyor, Oxford.
Whitehouse, J.	Surveyor to the Local Board, Eton.
Williams, H.	Surveyor to the Local Board, Pemberton; and West Houghton, Lancashire.
Wilson, J.	Surveyor to the Local Board, Bacup, Lancashire.
Wood, Joseph	Town Surveyor, Manchester.
Wright, J.	Borough Surveyor, Macclesfield.

TOWNS AND DISTRICTS REPRESENTED BY MEMBERS OF THE ASSOCIATION.

Acton	E. Monson.
Aldershot	J. Galsworthy.
Altrincham	J. Newton.
Alverstoke	J. W. Spond.
Ardwick	J. C. Holt.
Ashton-under-Lyne	J. Robinson.
Audenshaw	J. H. Burton.
Axbridge	W. Nicholson.
Bacup	J. Wilson.
Balsall Heath	E. Bettridge.
Barnsley	L. Kenworthy.
Barrow-in-Furness	H. Alty.
Basford	H. Walker.
Basingstoke	J. H. Moore.
Batley	J. Hildred.
Beccles	G. Fenn.
Bedford, Lancashire	G. Dickenson.
Beverley	J. Beaumont.
Birkenhead	T. C. Thorburn.
Birmingham	W. S. Till.
Blackburn	W. B. Bryan.
Blackpool	
Bolton	J. Proctor.
Bootle-cum-Linacre	G. Biddle.
Boston	W. H. Wheeler.
Bradford	J. Allisson.
Brampton and Walton	W. F. Howard.
Bridgewater	J. Parker.
Brighton	P. C. Lockwood.
Bristol	F. Ashmead.
Briton Ferry	H. F. Clarke.
Bromley	H. S. Cregeen.
Burnley	
Burslem	E. M Richards.
Burton-on-Trent	E. Clavey.
Bury	J. Cartwright.
Buxton	J. D. Simpson.
Cambridge	G. W. Stephenson.
Canterbury	J. G. Hall.
Canton	W. P. James.
Cardiff	T. L. Johnson.
Cheltenham	D. J. Humphris.
Cheshunt	L. Dewey.
Chester	J. M. Jones.
Colchester	J. Hope.
Congleton	W. Blackshaw.
Coventry	E. J. Purnell.
Crewe	G. Watson.
Croydon	T. Walker.
Dalton	W. H. Fox.

Derby	C. Dunscombe.
Dewsbury	B. C. Cross.
Dorchester	
Duckinfield	J. Cartwright.
Ealing	C. Jones (*Hon. Sec.*).
Epsom	J. R. Harding.
Eton	J. Whitehouse.
Exeter	H. P. Boulnois.
Fenton	J. W. Higginbottom.
Folkestone	W. E. Springall.
Garston	J. Standing.
Goole	E. C. B. Tudor.
Grantham	S. G. Gamble.
Great Grimsby	J. Maughan.
Halifax	E. R. S. Escott.
Handsworth	Rd. Hugh Burman.
Hanley	J. Lobley.
Harborne	W. Newey.
Harrogate	E. W. Harry.
Harwich	H. Ditcham.
Heaton Norris	
Hereford	G. Cole.
Hertford	T. W. Grindle.
High Wycombe	F. W. Burnham.
Hornsey	J. R. Rogers.
Hove	E. B. Ellice-Clark.
Hull	J. Fox Sharp.
Hulme	H. Royle.
Hyde	J. Mitchall.
Ipswich	E. Buckham.
Keighly	
Kendall	J. Banks.
Kidderminster	A. Comber.
Kingston-on-Thames	C. Dunscombe.
Lancaster	J. Hartley.
Leamington	R. Davidson.
Leeds	A. W. Morant.
Leek	J. Frost.
Leicester	E. L. Stephens.
Leigh, Lancashire	G. Dickenson.
Lincoln	
Littleborough	F. H. Shuttleworth.
Liverpool	G. F. Deacon.
Llandudno	T. T. Marks.
Longton	W. S. Mitcheson.
Lowestoft	R. H. Inch.
Macclesfield	Jabez Wright.
Maidenhead	E. Davey.
Maidstone	J. S. Anscombe.
Maldon	
Malling	F. J. C. May.
Malvern	J. E. Palmer.
Manchester,	J. G. Lynde (*Past President*).
Manor-of-Aston	W. Batten.
Merthyr Tydfil	S. Harpur.

Middlesbrough	E. D. Latham.
Milverton	G. F. Smith.
Newbury	B. Sargent.
Newcastle-on-Tyne	A. M. Fowler.
Newcastle-under-Lyne	J. T. Eayrs.
Newton-in-Makerfield	R. Brierly.
Northampton	J. H. Pidcock.
Norwich	C. Thwaites.
Oldbury	J. Devis.
Oswestry	E. B. Smith.
Oundle	G. Siddons.
Oxford	W. H. White.
Pemberton	H. Williams.
Plymouth	R. Hodge.
Portsmouth	J. E. Greatorex.
Prescot	W. Goldsworthy.
Preston	
Prestwich	S. C. Trapp.
Radford	J. Martin.
Ramsgate	
Reading	A. W. Parry.
Redditch	T. W. Baylis.
Reigate	J. H. C. B. Hornibrook.
Richmond	E. J. Pinkerton.
Rochdale	T. Hawson.
Ryde, Isle of Wight	
St. George, Gloucestershire ..	W. Dawson.
Sale	A. G. McBeath.
Salford	A. M. Fowler.
Scarborough	J. Petch.
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Sheffield	P. B. Coghlan.
Shrewsbury	G. J. Butler.
Southampton	J. Lemon (*President*).
Southport	W. Crabtree.
South Shields	M. Hall.
South Stockton-on-Tees	J. Hall.
Sowerby Bridge	J. H. Smithurst.
Stockport	J. Jackson.
Stoke-on-Trent	C. Lynam.
Stow-on-the-Wold	B. H. Valle.
Stratford-on-Avon	T. T. Allen.
Stretford	S. Kelsall.
Sunderland	C. Thwaites.
Taunton	J. H. Smith.
Teddington	T. Goodchild.
Tipton	W. Jépson.
Torquay	J. Little.
Toxteth Park, Liverpool	J. A. Hall.
Tranmere	W. A. Richardson.
Tunbridge	W. Noot.
Tunstall	R. Hales.
Twickenham	H. M. Ramsay.
Tynemouth	J. P. Spencer.
Ventnor	J. C. Livesay.

WAKEFIELD	G. Place
WALLASEY	J. T. Lea.
WALSALL	W. J. Boys.
WANSTEAD	J. T. Bressey.
WARMINSTER	T. Cruse.
WARRINGTON	R. Vawser.
WARWICK	E. Pritchard (*Vice-President*).
WATERLOO, LIVERPOOL	H. Hall.
WATFORD	G. E. Lovejoy.
WATH-UPON-DEARNE	S. Rodgers.
WEDNESBURY	J. W. Fereday.
WELLINGBOROUGH	E. Sharman.
WEST HAM, LONDON	L. Angell (*Past President*).
WESTLEIGH AND PEMBERTON	G. Dickenson.
WHITHINGTON	W. F. Howard.
WILLENHALL	B. Baker.
WILLESDEN	O. C. Robson.
WITHINGTON	W. J. Hardie.
WITTON-CUM-TWAMBROOKES	J. Holland.
WORTHING	J. Lund.
WOLVERHAMPTON	G. F. Thoms.

RULES OF THE ASSOCIATION.

I.—That the Society be named the "Association of Municipal and Sanitary Engineers and Surveyors."

II.—That the objects of the Association be—

a. The promotion and interchange among its Members of that species of knowledge and practice which falls within the department of an Engineer or Surveyor engaged in the discharge of the duties imposed by the Public Health, Local Government, and other Sanitary Acts.

b. The promotion of the professional interests of the Members.

c. The general promotion of the objects of Sanitary Science.

III.—That the Association consist of Civil Engineers and Surveyors holding permanent appointments under the various Municipal and Sanitary Authorities within the control of the Local Government Board, and such Honorary Members as shall be elected by the Council. Members who retire from their official position are eligible for re-election by the Council.

IV.—That the Affairs of the Association be governed by a Council, consisting of a President, Three Vice-Presidents, Twelve Members, and a Honorary Secretary, to be elected annually. The Past Presidents and the District Secretaries for the time being shall also be Members of the Council.

V.—That the Council shall nominate one name for President, six for Vice-Presidents, one for Secretary, and twenty-two Ordinary Members from whom to elect the Council. Such Nominations shall be printed and sent to each Member of the Association not less than thirty days previous to the Annual Meeting. Every Member shall be entitled to vote for or erase any of such Nominations, or substitute other names, subject in all cases to the limits of Rule IV., and return the same within seven days of the date of issue, and the Members who shall obtain a majority of votes shall respectively be duly elected President, Vice-Presidents, Members of Council, and Honorary Secretary for the ensuing year.

VI. That the Association be formed into District Committees which shall include the whole of the Members. Such Committees shall meet from time to time, in convenient centres, for the discussion of matters of local and general interest connected with the Association. Each District Committee shall appoint a Local Secretary, who will keep records of local proceedings, and communicate with the Council. No District Committee or Local Secretary shall be entitled either to represent or act on behalf of the Association.

VII. That a General Meeting and Conference of the Association shall be held annually in such towns, in rotation, as may afford convenient centres for assembling the Members.

VIII. That an entrance-fee of One Guinea, and a subscription of One Guinea per annum, from Civil Engineers and Surveyors under Rule III., shall constitute Membership of the Association.

SUBSCRIPTION ACCOUNT.

	£	s.	d.		£	s.	d.
Arrears from last year	30	9	0	Received for Arrears	8	8	0
Subscriptions due from Members	173	5	0	" Subscriptions	130	4	0
Admission fees	6	6	0	" Admission Fees	6	6	0
				Balance—Arrears due	65	2	0
	£210	0	0		£210	0	0

CASH ACCOUNT.

Receipts.	£	s.	d.	Expenditure.	£	s.	d.
Balance from last year	52	9	0	Home Counties District	10	14	8
Arrear Subscriptions	8	8	0	Midland District	13	12	4
Current "	130	4	0	Lancashire and Cheshire District	1	14	6
Admission Fees	6	6	0	General Expenses—			
At Manchester Meeting	22	1	0	Printing and Stationery	8	1	8
Additional copies of Proceedings	2	0	0	Advertisements	0	13	3
Sale of Proceedings	8	2	0	Expenses at Manchester Meeting	37	0	6
				Reporting at ditto	16	18	8
				Printing Proceedings	82	11	0
				Stamps	12	10	6
				Secretarial Expenses	10	10	0
				Petty Cash Sundries	3	3	10
				Balance carried forward	31	19	1
	£229	10	0		£229	10	0

I have examined the above Accounts and compared them with the vouchers and receipts, and certify them to be correct, and that the balance in hand at the close of the Subscription year 1876 is £31 19*s.* 1*d.*, and that the amount of arrears due is £65 2*s.*

Dated 2*nd July*, 1877.

(Signed) Albert W. Parry, *Auditor*.

ADVERTISEMENT.

The Association is not responsible for the statements or opinions advanced in the Papers and Discussions contained in the following pages.

ASSOCIATION OF MUNICIPAL AND SANITARY ENGINEERS AND SURVEYORS.

THIRD ANNUAL MEETING.

July 6th and 7th, 1876.

HELD AT THE INSTITUTION OF CIVIL ENGINEERS, GREAT GEORGE STREET, WESTMINSTER.

Thursday, July 6th.

IN opening the proceedings, the President, M. J. G. LYNDE (City Surveyor, Manchester) said: Gentlemen,—I have the pleasure of meeting you again, and I will propose, if you please, that the minutes of our last meeting be taken as read. You all have a copy of those minutes, and they are rather long for the Secretary to go through again; but if any gentleman has any remarks to make upon them I shall be very, very happy to hear him; if not, I will put it to the meeting.

The PRESIDENT: Will you take the minutes as a correct record of our proceedings at Manchester?

The Members having signified their approval, the minutes were taken as read and confirmed.

The PRESIDENT then called upon Mr. C. Jones (Ealing), Honorary Secretary, to read the Annual Report.

THE REPORT OF THE COUNCIL OF THE ASSOCIATION OF MUNICIPAL AND SANITARY ENGINEERS AND SURVEYORS FOR THE YEAR ENDING MAY, 1876.

GENTLEMEN,—It is with much satisfaction that the Council of your Association meet you on the present occasion; and in this, the Institute and head-quarters of Civil Engineers, present to you their Report for the year ending in May last. The past year, if not so full of apparent energy as the years that have preceded, has

been doubtless one of much practical usefulness, and in which the objects of the Association have been fully and successfully carried on.

The first years were, to some extent, years of novelty, and in which the bonds of union brought about by the numerous meetings, held, were made a means to an end, viz. that of sound and practical working in the particular branch of the profession to which we directly or indirectly belong. That the result has been satisfactory the various papers already published, the influence exercised, and the recognition accorded, even in the highest quarters, abundantly prove. A spirit of inquiry has been engendered amongst the Members which must bear the most important results, not only as regards our individual operations, but to the community at large, and the fact that the Members of the Association are really the executive in one of the most important branches of our national institutions has impressed itself upon the minds of all thinking and observant men.

The question of sanitary legislation, from the governing bodies of our Legislature to the smallest Board in the kingdom, is one that stirs up the thinking power of all who are associated with these several bodies, and whether it be the drainage of hundreds of square miles in the Thames Valley at an expense of millions, or the expenditure of a few hundreds in rectifying the sanitary crudities of some comparatively unknown village, the influence and the information brought to bear upon it by an association such as the one we now represent, is of the utmost practical importance.

Your Council has much pleasure in reporting that the number of Members has increased rather than otherwise. Death and resignation of office has taken some names from the list, but the number has been made up by accessions to our ranks, the number upon the books being 170, and representing, with one or two exceptions, every important town in England, and some few in Wales. The Proceedings for the year 1874–75 are in the hands of Members, and the Council cannot but express their sincere thanks to our new and first President for the kind and efficient way in which he has edited the same. The funds are satisfactory, although small, a balance of some 50*l.* remaining after the various expenses connected with the year are paid.

During the past year meetings of the Lancashire, and Cheshire, Midlands, and Home Counties District Committees were held at Cheltenham, Oxford, Warwick, Blackburn, and Manchester.

The following is the result of the ballot for officers for the ensuing year:—

President—J. Lemon.

Vice-Presidents—Messrs. Deacon, Morant, and Pritchard.

Council—Messrs. Ashmead, Clark, Coghlan, Fowler, Greatorex, Harpur, Lockwood, Purnell, Supereor, Till, Thorburn, and Vawser.

Hon. Sec.—C. Jones.

The President: Gentlemen, you have heard the Report the Council have to present to you. It is for you now to express your opinion upon it, and I shall be happy to hear any remarks; anything that may be said will be taken as friendly criticism by the Council, and the in-coming Council will be willing to act upon any suggestions that may be thrown out.

Mr. E. R. S. Escott (Halifax) said he was not present when the Report was begun, but having heard that portion which referred to the amalgamation of Yorkshire and Lancashire, he hoped the Council would carry it into effect.

Mr. Monson (Acton) said, certainly the Home Counties had not much work and he was sorry there were not more frequent meetings. He had attended the meeting at Blackburn, and he was so pleased with the street paving that he saw there that he had adopted it in his own parish. With regard to the Proceedings, they seemed to be rather short of information. Now, that was a very valuable description they had heard at the Fire Engine Station at Manchester, that would have been useful to have been printed. At the Police Station, too, he considered they had some very valuable information. They also visited the Abattoir; and he thought if particulars of these had been given they would have proved very useful and interesting.

Mr. C. Jones (Hon. Sec.) said the Members would readily perceive the difficulty of reporting such out-door meetings as those referred to without the aid of shorthand writers. In the future, however, he should be happy to manipulate a report of such gatherings by obtaining the information from those who could supply it. He considered it desirable to have Reports of their visits last year to the Fire Station and Abattoir, and it would not be unwise to endeavour to get such descriptive Reports to be included in next year's Proceedings.

Mr. Angell (Past President) said the fact was that when they got out of doors at Manchester the Members split up into various

parties, and if detailed Reports were given of every visit made, such as to the Town Hall, Waterworks, Gasworks, Police Station, Fire Station, Abattoir, Dustyard, Sewage Works, &c., it would be necessary to depute a reporter to attend each party. Again, referring to the lateness of the publication of the Proceedings, he said he had had a most difficult task. He intended to have issued them six months earlier, but a combination of circumstances had prevented him. The shorthand notes supplied were excellent, but from some want of arrangement at Manchester a number of the papers were lost. He was told the newspaper reporters had taken them away, and he had to ask some of their friends to rewrite their papers; then some of the rewritten papers were altered from the originals, and the Members could hardly form an opinion of the trouble he had in rearranging the speeches already in type so as to fit in with the rewritten papers. Again, when he sent proofs to the respective Members for revision, some were kept a month or six weeks, and then they had written for another proof, having lost the first. Finally came the binder's error. These were a few of the facts he mentioned as illustrative of the difficulties he had to contend with as an amateur editor. Members must also remember that his own time was very much occupied. This was the apology he had to make for the Proceedings being so late and not so complete as he could have wished, and he hoped the Members would at that meeting hand over the papers as soon as read.

Mr. James Lemon (President Elect) said: We are very much indebted to Mr. Angell, and the remarks which have been made were not intended to apply to him, but with the view of obtaining some improvement in the future arrangements. A great deal of this matter rests with the local secretaries; they ought to be responsible for papers read by Members of their district. In visiting the different localities the local secretaries should secure the services of the press, who are always willing to accompany them, and a reporter would follow the visits and take down notes of remarks made by gentlemen who conduct them. On the occasion of their visit to the Abattoir, for instance, if the information imparted by Mr. Lynde and others had been taken down and entered in the Proceedings it would have been of great service.

Mr. E. B. Ellice-Clark (Hove) said it could not be expected that their Honorary Editor should take notes of all their different visits.

Mr. Lemon: The local secretaries should send the information.

Mr. C. Jones said a resolution had that morning been passed by the Council, stipulating that all papers shall be printed *in extenso*, and that proofs be sent round to the Members reading them, who would be at liberty to alter or expunge anything they might think proper to do.

Mr. Angell thought such a resolution was neither necessary nor expedient; it had been the custom to print in full the papers that were read at the annual meetings. Some of the district papers had been modified, for which he thought the authors were indebted to him. He was late that day, but had he been present at the Council he should have objected to such a resolution. He thought the publication of papers *in extenso*, or otherwise, was a matter that should be left to the discretion of the Council; a paper consisting of sheer nonsense might be read; it did not follow that it should go into print, but such would be the case if the resolution were confirmed. He was sorry to oppose a resolution of the Council, but not having been present when it was passed, he could not but express his objection to such a rule. Suppose a man to be elected Surveyor under some of those invitations to give his whole time for 100*l.* a year; this man, feeling the dignity of his new office, and being of right eligible as a Member of the Association, might write a paper with the sole object of having it published, but the natural inference would be, that a man whose qualifications could only command so small an appointment was not qualified by either education or experience to instruct the Members of the Association by any paper he might write; but if such paper were written, however unsuitable or whatever its defects, it would, according to the new resolution, appear in the Proceedings *in extenso*.

Mr. E. B. Ellice-Clark: Are not the papers submitted to the Council before being read?

Mr. Angell observed that the papers read at the district meetings have never been submitted to the Council; indeed, such was the dispersed character of the Association, that district papers could not be so examined.

The President said he understood the resolution to mean, that papers read be printed, subject to any alterations by the Council; after such alterations were made the paper would be submitted to the writer, and if he approved of them the paper would be printed; but if he did not approve of them, it must be withdrawn.

Mr. Angell: It is not so stated in the resolution, which should be modified accordingly.

Mr. Jones (Hon. Sec.) suggested that an addition to the resolution would meet the difficulty, viz. that papers proposed to be read should be submitted to the Council before printing, and any alteration in the same to be submitted for the approval of the writer, but the printing of any paper should be at the discretion of the Council.

The President: Does anything else occur to anyone in the Report?

It was moved by Mr. Deacon (Liverpool), seconded by Mr. Coghlan (Sheffield), and carried unanimously, that the Report of the Council be adopted.

The President: I have to thank you on behalf of the Council for signifying your approval of the Report. The suggestions you have made will receive every consideration at the hand of the new Council, and I think we shall all improve and benefit by them. We could have done nothing without your support; you have borne with us. As for as I am concerned, I have fallen far short of what I should have liked to have done to advance the interests of the Association. I have great pleasure now in vacating my chair and in making room for Mr. Lemon. I feel he will fill the chair very effectually and do a great deal more for the Association than I have been able to find time to do. The Association will lose none of its prestige, but will gain a great deal while Mr. Lemon occupies this chair.

Mr. James Lemon (Borough Engineer of Southampton and President Elect) then assumed the office of President for the ensuing year.

Mr. C. Jones (Hon. Sec.) said there seemed to be no other question to be raised for discussion. They had been exceedingly unfortunate in fixing the meeting for that week; the Assizes were on in the different towns, and Member after Member had written to him to say they were professionally engaged, in fact he had himself received a subpœna for the Nottingham Assizes. Mr. Greatorex, who was one of those detained, had sent up his paper to be read, and Mr. Thorpe was also prevented from being present. He also read a letter from Mr. Harpur, one of the Council, regretting inability to attend.

THE PRESIDENT'S ADDRESS.

GENTLEMEN,

I have to thank you most sincerely for electing me to the honorable position of President of this Association of Municipal and Sanitary Engineers and Surveyors.

Sanitary Engineering is of comparative modern growth, as it may be said to have sprung into existence less than thirty years ago.

We are indebted to Mr. Edwin Chadwick and Dr. Southwood Smith for their investigations into the causes of zymotic disease and for their very able reports; the result being the Towns Improvement Act of 1847 and the Public Health Act of 1848, which were followed by a host of sanitary Acts down to the present time.

The adoption of the Public Health Act of 1848 necessitated the appointment of "the Surveyor," and so much importance was attached to the position of this officer by the Government of that day, that his removal was subject to the approval of the General Board of Health. When that board ceased to exist, the sanction or approval of such removal by the central authority was no longer required: a retrograde step in sanitary legislation which I hope to see remedied.

Sanitary authorities appointed the best officers they could obtain; some were gentlemen of ability, but the large majority necessarily possessed but a limited knowledge of sanitary science.

The demand thus created for special knowledge naturally induced civil engineers and surveyors to devote themselves exclusively to the study of this important branch of the profession, and the result has been the creation of the Sanitary Engineer.

But it has been reserved to this Association to take legitimate steps to bring together the official talent of the country, and to adopt means of instruction whereby the standard of knowledge of sanitary science amongst its members may be permanently raised. That this is already the case, no one will deny; that it will steadily go on is my earnest hope, and no effort of mine shall be wanting to effect this object.

This brings me to the present position of towns and districts, under the Public Health Acts, and the duties of their officers.

The first duty of the sanitary authority is the removal of excremental matters: this brings into play the constructive skill of the Sanitary Engineer and the chemical knowledge of the Medical Officer of Health.

So much has been said and written on what is called the "sewage question" of late years, that I shall not refer to it at any length on the present occasion. It is, however, satisfactory to know that great differences of opinion now no longer exist, and that there is a healthy tone of general accordance on main points, which augurs well for the settlement of the most difficult problem in sanitary science.

A few years ago, the water carriage system was strongly supported as applicable to *all* towns and districts, whilst its opponents strongly advocated the claims of the dry system.

It may now be fairly stated that the strong partisans of a system under all conditions, and in every place, are very few in number, and as time rolls on they will gradually disappear. The more we study the subject, the more we become convinced that the choice of the system must depend entirely upon local circumstances.

The removal of the old-fashioned privy and midden, with all its attendant evils of damp subsoil and the pollution of drinking wells, and the substitution of the water-closet and dry-closet have resulted in a reduction of the death rate and a decrease in sickness.

Closely allied with town drainage is the disposal of the sewage at the outlet. All towns labour under this difficulty, those with a water carriage system and those with a dry system, as the latter system does not prevent the pollution of rivers by slops and the waste water from factories and chemical works. Sewage utilization or purification has been the subject of much controversy, and large sums of money have been expended in the attempt to solve the problem, but the advocates of irrigation, precipitation, and filtration have come to the conclusion that sewage utilization does not pay, that the attempt to make a profit out of sewage must be given up, and that it must be treated as something to be got rid of without nuisance. Local boards must either pay a subsidy to public companies, or they must make an annual loss if they elect to do the work themselves. In either case there must be a charge upon the rates.

If the sewage outlet is above the intake of the water supply of another town, then the best means of purification is to apply the sewage to the land.

If this condition does not exist, then precipitation or filtration

may be resorted to, but in every case the standard of purity of the effluent water should not be lower than that of the river into which it is discharged.

The supporters of irrigation and precipitation now hold considerably modified views, they no longer oppose each other at every opportunity; experience and discussion have taught them that both systems can be beneficially adopted under different local conditions, and that a combination of the two systems has its advantages. This has been successfully carried out in some towns, more especially at Barking, where the matter in suspension is removed by the phosphate process, and the matter in solution by application to the land.

There are many details connected with the drainage of a town to which the attention of this Association should be specially directed, with the view of acquiring by discussion a better knowledge of the subject, and more uniformity in working, for example.

I have compared the provision made for sewage in tanks per head of the population, and I find there is a very great difference in various towns. This is a simple matter, but it illustrates very forcibly the importance of a free interchange of thought, and that every member who is entrusted by a local authority to expend the money of the ratepayers ought to be able to give a reason for what he does, and his works ought to bear the criticism of his professional brethren.

Amongst the many subjects upon which I hope to hear papers read and statistics given, are—

1. Sewage Pumping Machinery.

2. The Separate System.

3. The area of land for Irrigation and for Intermittent Filtration per 1000 gallons of sewage, exclusive of rainfall.

4. The Drainage of Sewage Farms, the formation of the land, and the cost per acre.

5. The cost of precipitation by various processes, and the cost of drying the sludge.

I do not ask members to advance theories upon these details, but to give the Association the results of their own experience gained by careful study and observation of works under their charge. As engineers we should build upon the solid foundation of actual experiment and research.

Much money has been spent in sewage experiments, but that is only the natural outcome of a desire to promote sanitary progress;

let us, as an Association, give each other mutual assistance, and so raise the standard of knowledge amongst our members.

At the late conference at the Society of Arts strong opinions were expressed in reference to the defective condition of house drainage, and as to the desirability of the work being done by the local authority.

This is in many cases correct, but we must avoid paternal government in these matters. Local boards have ample powers to enforce the construction of efficient drainage, but it can only be done by an increased staff of inspectors, involving increased annual expenditure. Whether the inspection of buildings should be paid for by fees, as in the Metropolis, is a matter for serious consideration.

The Government, as you are aware, are promoting a Bill for the prevention of the pollution of rivers.

The Bill, on the whole, is a very good measure, as it does not aim at too much, and the clauses are clear and intelligible.

But in saying this much for the Bill, I wish to point out what I consider a defect, and that is the powers under Clause 8 to enable manufacturers to carry the liquids proceeding from their factories or manufacturing processes into the sewers of the local authority, on such terms as to compensation (if any) as may be determined by agreement, or in default of agreement, as may be settled by arbitration; with a provision that the section shall not extend to compel any local authority to admit into their sewers any liquid which would prejudicially affect the disposal by sale, application to land, or otherwise, of the sewage matter conveyed along such sewers.

This section would give encouragement to manufacturers to carry such liquids into the sewers, to the serious detriment of the purification of the sewage.

The Sewerage Committee of Wolverhampton, in their report of the 1st of May, 1876, draw the serious attention of the Town Council and the public to the great damage sustained to crops through acids being allowed to run into the sewers from manufactories in the borough, and they strongly urge upon the manufacturers the importance of neutralizing the acids and other injurious refuse from their works before allowing them to flow or pass into the drains, or of altogether preventing the same from entering the sewers; and unless some such steps are taken the Committee propose to instruct the Town Clerk to take proceedings.

The Sewage Inquiry Committee of Birmingham, in their report

of October, 1871, also recommended the exclusion from the sewers of the refuse from the works of brassfounders, galvanizers, manufacturing chemists, and others; and Professor Frankland, to whom samples were submitted for analysis, reports that the said refuse can be converted into marketable salts, which will nearly, if not quite, repay the cost of manufacture, while the acids and tar products can be disposed of by being evaporated in the ashpits of any furnaces used in the factories where they are produced.

These two large towns, under the guidance of an able committee in each case, may be fairly taken as evidence of the desirability of excluding such refuse from the sewers on any condition whatever, and admitting only the effluent water at such a standard of purity as shall be approved by the local authority, with power of appeal in case of dispute to the Local Government Board.

If this Bill become an Act this Session, which is exceedingly doubtful, it will cause a revolution in the condition of our rivers in the manufacturing districts. But in enforcing its provisions some discretion should be exercised; the worst cases should be taken first, and the standard of purity of the effluent water gradually and not suddenly raised.

If it is pushed forward arbitrarily against vested interests, a reaction will set in detrimental to the progress of that sanitary work we all desire.

The next subject to which I wish to direct your attention is that of water supply. Since our last annual meeting we have had an excellent paper on the water supply of Warwick by Mr. Pritchard, Vice-President, and we are promised a paper by Mr. Greatorex, of Portsmouth, which I hope will be fully discussed.

The importance of good water cannot be over-estimated; all towns which are without this vital necessity have a high rate of mortality and a heavy percentage of zymotic disease.

Local authorities who take no steps to prevent their constituents from being poisoned by bad water should be held responsible for such neglect, and the Local Government Board should compel such local authorities to provide a constant supply of a fixed standard of purity within such time as they may direct.

It is open to any ratepayer to make complaint to the Local Government Board; but few persons will go to the expense of an analysis, and water containing the germs of disease is often pleasant to the taste, and even sought after by those who are ignorant of its ill effects.

The central authority very properly compel local boards to drain their districts; injunctions are easily obtained against the pollution of rivers; and the Government have a Bill before the Commons giving them increased powers; but the supply of one of the necessaries of life is left to chance and the voluntary efforts of water companies.

Towns should not be left to the tender mercies of public companies, whose chief desire is to keep up their dividends, but the water supply should be in the hands of the local authority, and an analysis should be made by an independent officer under the central authority at least once a year.

The influence of this Association has already made itself felt, and last year we succeeded in getting a useful addition to the clause in the Public Health Act in respect of the compulsory supply of water; further amendment is, however, necessary. Powers are given to the local authority to compel the owners to supply water to their houses, at an expense not exceeding the water rate of the local act; but corporations who have constructed their own works are still liable to the limitation of 2*d.* per week, unless they apply to the Local Government Board. This absurd regulation was no doubt intended to protect the poorer classes; but it is not the occupier who is the objector, it is the owner, who wishes to avoid the expense of laying on water from the main to his houses.

One of the necessaries of life was only considered worth 2*d.* per week for a family consisting of five persons on an average. What Sir Wilfred Lawson would think of such a clause I leave my hearers to imagine!

The last two or three years have witnessed great changes in the ownership of waterworks. Companies have been induced by the offer of large premiums to sell their works to corporations, and in one case, that of Stockton, compulsory powers were given the local authority to purchase.

But although it is extremely desirable that these transfers should be made, I fear there is a tendency on the part of corporations to give exorbitant terms, to the detriment of the consumer. Parliament would act wisely if they encouraged these transfers on the basis of annuities equal to the maximum dividends, and not upon the now prevalent system of so many years' purchase upon the dividends or profits.

Again, corporations might be allowed to hold shares in water-

works, by consent of the Local Government Board, by which means they would gradually become the entire owners of the property.

The question of water supply naturally brings me to the consideration of public baths and washhouses.

An Act was passed in the year 1846, and amended in 1847, "to encourage the establishment of public baths and washhouses," but, like all permissive legislation, it has failed to accomplish the object for which it was passed.

Very few towns have adopted it, from the fear of increased local taxation. In these days of active legislation for the labouring classes, and for the promotion of temperance, sanitarians should not overlook cleanliness and home comforts. The Artizans Dwellings Act is a step in the right direction, but public baths and washhouses should form part of the scheme. There is nothing more likely to drive the workman to the beershop than a room full of wet clothes on a washing-day, to say nothing of damp walls and other discomforts.

If local authorities could see their way to adopt this Act without loss, they would be induced to do so; it is therefore the duty of this Association to try to solve the problem. Carefully-considered plans and estimates of cost, with statistics of working expenses, would be useful, and I hope one at least of our members will take up the question before our next annual meeting.

That the adoption of the Act is not always a loss has been proved by the Bermondsey Vestry, the result of the last year's working (the twenty-third) being a profit of 300*l.*, which was carried over to the credit of the poor rates.

Amongst the many duties of the Local Surveyor there are none requiring more close attention than those in connection with the maintenance of the public highways.

A well-paved town plays an important part in forming habits of cleanliness amongst the inhabitants. Dirty, ill-paved streets, with pools of stagnant water, are always accompanied by dirty homes and often by disease amongst their owners.

Great advances have been made in this respect, more especially in London and the large provincial towns. It has been well said "that no surer indication of the trade of a town can be given than the existence of good and sufficient means of internal communication."

I do not intend in a short address to travel over the whole range of this large subject as the Association will have the benefit of some

excellent papers, which I hope will be fully discussed, but I wish to draw the attention of members to the importance of carefully prepared statistics of the cost of maintenance. The cost must depend upon local circumstances, but still there are many conditions in common in all towns and much valuable information could be mutually afforded.

Everybody thinks he can make a road, yet how few succeed, and what a large sum is annually spent by municipal authorities.

I believe all public officers do their duty in keeping down expenditure consistent with efficiency, yet few know the cost per square yard for maintenance, cleansing, and watering of their roads per annum, under various conditions of traffic, but I hope we shall all supply this information to the Association for our mutual benefit. I will undertake during my year of office to send out the necessary list of questions.

The introduction of asphalte and wood paving, or I might more correctly say the re-introduction, has caused more attention to be paid to our public roads. If asphalte has done nothing else, it has certainly raised the standard of excellence as regards surface. Macadamized roads are struggling to put on the best face they can; this desire for a smooth and even surface has brought the steam roller into use in large towns, and the loose stones are now no longer ground to powder by the wheels or put out of place by the horses' feet.

The effect of well-paved surfaces is felt in a variety of ways, irrespective of cleanliness. There is improved traction and consequent saving of horse labour and decrease in the deposit in our sewers.

Mr. Till, the Borough Surveyor of Birmingham, when requested to advise his committee as to the best means of preventing the passage of street silt into the sewers, recommended a systematic paving of the streets.

I am pleased to see the town council have taken up this subject with their usual energy and public spirit, having resolved to expend 150,000*l.* in paving.

We now have, thanks to Mr. Haywood, the exact average distance a horse will travel on wood, asphalte, and granite before he falls, and much more valuable information thereon; but still there appears much difference of opinion amongst the city commissioners as to the respective merits of wood and asphalte.

I have reported so fully on both these materials, and my remarks

have been so often quoted, that I need not repeat myself here, but I will hand a copy of my reports to our honorary editor as an appendix to our "proceedings," which may prove useful to some of our members.

I cannot help thinking that if our ancestors in the days of sedan-chairs could see the street paving of to-day, they would admit we had made some progress; but mutual congratulation is not our object; much has been done, but much more remains to be done. We have secured an even surface, but it has been at the cost of slipperiness in asphalte and non-durability in wood.

Whatever opinions we may have as to the best material for our roads, there cannot be a question as to the suitability of asphalte for public footways. The absence of joints, its non-absorbence, and its comparative cheapness render it a very valuable material, but in selecting asphalte my experience teaches me that the best description is the cheapest, and care should be taken not to use bastard compositions. I have a preference for the compressed asphalte, as nothing but the genuine rock is used, but very good mastic footways are laid, that on Westminster Bridge being a good sample.

The formation of new streets, or as they are called "Private Improvements," under the well-known clause 69 of the Public Health Act of 1848, now clause 150 of the Public Health Act of 1875, has been the cause of much controversy, and much contrariety of opinion still exists. There are great differences in the cost per foot run in various towns, some authorities stipulating for kerbing, channeling, and paving to the footways, whilst others are satisfied with kerbing only in the suburban districts.

In urban districts the clause of the Act should be carried out in its integrity, but in the outlying districts paving may fairly be dispensed with. Of course the paving is only a question of time, and the effect of postponement is an immediate relief to the large landowners at the expense of the ratepayers, but still a good deal may be said as to the advisability of treating the rural portion of a borough on a different basis to that of a town proper.

Then as to the mode of payment, some authorities collect the money in a lump sum, and others distribute the payment over a number of years.

The repayment in yearly instalments of principal and interest is no doubt a relief to the owners, and it enables the local authority to spend more money and get the work more efficiently performed, thereby effecting a saving in the annual maintenance.

The preparation of the plans and specification, and the superintendence of the work, are thrown upon the surveyor; and also the apportionment of the cost according to the frontage of the respective premises. These duties give the surveyor a great deal of additional work and involve some responsibility.

Whether large landowners should thus get the roads through their estates well and economically made by the local surveyor, without payment of the usual professional charges, is a matter demanding inquiry. I know some authorities charge 5 per cent., but that includes the cost of collection, about 2½ per cent., and the remaining 2½ per cent. does not pay for the work done by the surveyor's department.

The cost of new streets should fall upon the freeholder, and not upon the small leaseholder, as he (the freeholder) reaps a very large profit by the transfer of his property from agricultural to building land. I know cases where land now lets at upwards of 100*l.* per acre as a ground-rent, which five years ago was let at 4*l.* per acre. It is therefore only just that landed property should bear its fair share of local taxation.

I am aware that landowners consider themselves very ill used, and they are constantly praying that their local burdens may be removed and transferred to the Consolidated Fund; but if they are unfairly treated, what about the poor householder who has to bear all the local expenses under the various sanitary Acts, of permanent works and their maintenance, as well as all other expenses under the head of the poor rates and borough rates?

I have long been of opinion that the incidence of taxation in towns requires adjustment, and that the cost of permanent works, or a portion thereof, should be paid by the owner, and the maintenance by the occupier, with power to the leaseholder to deduct the proportion of the rating from the ground-rent, the same as property tax.

This principle is partly carried out at the present time in London, in respect to the sewer rate and main drainage rate, and is found to work satisfactorily, and it might be extended with beneficial results.

But as taxation and representation should go together, I would give a vote to the owners in boroughs for the election of members of the town council. This would bring about greater interest in local matters on the part of the upper classes.

These remarks are a divergence from my subject, but sanitary

works and taxation are so closely allied that very little progress can be made with the former unless the latter is fully and fairly considered.

There is a large majority of persons who will advocate everything which has a tendency to improve the health of the town in which they reside providing it does not cost anything, but directly you touch the pocket of the British ratepayer, it is astonishing how his views change, and what abundant reasons he will find in favour of an indefinite postponement of the proposed improvement.

We have lately received an addition to our sanitary legislation which will put local self-government on its trial. I allude to the Artizans Dwellings Act of last year. Birmingham has set to work in earnest to carry out the Act in a manner which reflects the highest credit upon the late Mayor, Mr. Joseph Chamberlain, M.P., and the borough council, but I fear few towns will follow the example.

Mr. Cross has lately done something to forward the work by his justly merited rebuke to the Metropolitan Board of Works on the insufficiency of their scheme: the result I hope will be the substitution of a comprehensive scheme to remove the rookeries of Gray's Inn Lane, worthy of the well-earned reputation of the Board.

The difficulty which I see in putting the Act in force is the definition of an unhealthy area. The preamble is everything that can be desired, but Clause 3 defines it as an area where diseases indicating a generally low condition of health amongst the population have been from time to time prevalent, and it goes on to state the causes to which those diseases may be attributed. But this, in my judgment, is not sufficient. All courts and alleys wanting in light, air, ventilation, or proper conveniences should be declared an unhealthy area, whether sickness prevails or not. I know some districts in my borough where the rate of mortality is not above the average of the borough, but directly an epidemic sets in, these districts suffer severely; they are ripe for disease, but under ordinary conditions they escape. They are like a city built of wood; they may go on safely for years, but when a conflagration takes place, the whole are swept away. Such tinder-boxes should not be allowed to remain until the torch of disease is applied. Sanitary measures, if they are to be effectual, should be preventive and not remedial.

When the inquiry was held at Birmingham, evidence was given as to the high death rate of the locality proposed to be improved, and the whole tenor of the Act, especially the clauses in reference

to the default of the local authority, leads to the inference that disease must be prevalent before the district can be considered an unhealthy area.

If we are to lessen crime and drunkenness in our large towns, we must provide healthy, well-ventilated homes for the working classes, and not wait until their present houses are either unfit for habitation, or that diseases are prevalent therein.

The Home Secretary is evidently prepared to give the Act a wide interpretation and to carry out the spirit and intention, but his successor may read it differently, and adhere to the strict legal definition. This is, I think, sufficient reason why the Act should be supplemented by an Improvement of Towns Act; the words "improvement scheme" are used in the third clause, and the same powers should be given to local authorities and enforced against them as regards opening up crowded localities, whether unhealthy or not, as are now given under this Act.

It often happens that improvements of streets could be carried out to a great advantage if the local authority possessed compulsory powers. An "improvement scheme" could be prepared and approved by the central authority, after local inquiry, under the same conditions as the Artizans Act, and carried out from time to time as the opportunity arises, which would be productive of very beneficial results.

Large towns in many instances have obtained private Acts which give them powers to make improvements and regulate new buildings; and although a large number of persons are congregated together, there are not such glaring cases of insufficient accommodation for the poorer classes as is to be found in smaller towns; then why the limit of population was fixed at 25,000 below which the Artizans Dwellings Act shall not apply does not appear. Perhaps the Government looked upon the Act as experimental, and wished to see the working in large towns before they extended it to the smaller; or perhaps they were of opinion that only the large towns were likely to voluntarily carry out its provisions, by reason of their being governed by men of more enlarged views. Whatever opinion they may have entertained, it is, I think, admitted that small towns require the Act as much as the large ones, and even more so. We have now rural sanitary authorities who will, I hope, take up this question, and publish to the world how the agricultural labourer is lodged. We should then, I think, have some startling revelations. Many of the so-called cottages compare unfavourably with the stables of the

squire, and, in the words of the Act, "diseases indicating a generally low condition of health have been from time to time prevalent."

In order to carry out this Act, the surveyor will have to prepare an "improvement scheme," with estimates of the cost, and to give evidence at the local inquiry.

The land purchased is to be sold, or let by the local authority, and they shall not themselves undertake the rebuilding without the express approval of the confirming authority, but in either case the duty of designing artizans' dwellings will devolve upon the surveyor, as the local authority must impose suitable conditions and restrictions as to *elevation*, *size*, and *design* of the houses, and the extent of the accommodation to be afforded thereby, and make due provision for the maintenance of proper sanitary arrangements.

This will be a work of considerable labour, and I hope it will be met by corporations in a liberal spirit. The estimate of cost will not only include the purchase of the buildings and land but the cost of the proposed new streets, if any, and the increased rateable value of the new property will have to be taken into account. A careful balance-sheet of the proposed expenditure and probable receipts should be prepared showing the annual loss. That there will be a loss, I have no doubt, and, from the experience I have had in laying out new streets, I should estimate that loss at 50 per cent. of the whole cost at the least.

But although this loss will fall upon the rates there will be a gain to the poorer classes living upon unhealthy areas, from the decrease in their expenditure in times of sickness, and from the diminution of enforced absence from their daily toil.

But these broad views, I fear, are not likely to influence those who will oppose any increase in rates, and time will prove whether the Government will exercise their compulsory powers, without which very little progress will be made.

At the same time I must record my opinion that the Artizans Dwellings Act reflects the highest credit upon the Government and the Legislature.

Great responsibility is thrown upon the surveyor, and the success or failure rests in a great measure with those who have to carry out the provisions and work out the various details. I think I may safely say that the members of this Association will not be found wanting.

The consideration of this important measure naturally leads one to reflect as to the causes which led to its passing, and the answer

is "laxity of local control over the formation of new streets and buildings." Nearly all our sanitary legislation has been framed to remove existing defects, and it was not until the year 1858 that complete powers were given the local authority to check the rapid growth of this evil, and to frame preventive measures.

But as the power to make Bye-laws was only permissive and not compulsory, many local authorities did not avail themselves of the power until several years after, and some have not done so at the present time.

Courts and alleys have been allowed to be created, and back-to-back houses built, without through ventilation. These evils the Artizans Dwellings Act will remove, but how much better it would have been if the minimum width of streets and building regulations had been defined by Act of Parliament and not left to the local authority to legislate upon by means of Bye-laws.

Two years ago, at our annual meeting at Birmingham, I read a paper on this subject, and the general opinion was strongly in favour of a Borough Building Act in lieu of Bye-laws, but as the local conditions vary considerably, an Act of this kind could not be framed to work satisfactorily without that local knowledge and assistance, which an Association like this alone can give.

I shall consider it my duty at an early day to call the Association together to discuss this question and to prepare suggestions, which, I hope, will be accepted by the Local Government Board.

Mr. Lynde (Past President): I have much pleasure in moving that a cordial vote of thanks be given to the new President for his very interesting and instructive address. He made some interesting remarks about house drainage and private works, and he also said something about the cost of collection; we know what that costs us in Manchester: it costs us nothing, we don't begin work till they bring us the money. As to the question of water supply referred to by our President, I don't know why public analysts in large towns should not analyze the water as taken from the taps, in houses, as well as that there should be a weekly or monthly report on the supply of gas. It would be just as well to entrust the analyst to examine the water periodically as the gas. As regards the street paving, I shall not say one word in anticipation of the paper we shall have from Mr. Royle, but I may allude to one interesting fact that astonished me and others. We have a large hotel opposite the Infirmary, and the heavy traffic that passed along the street, having

a clay subsoil, so shook the house, that the landlord could not keep his port wine, and other wines that require to be kept still, in the cellar, and the crockery and ornaments were nearly shaken from their places; in the end he was obliged to move his cellars some distance at the back of the house. We were doing some work in that neighbourhood, and amongst other things we asphalted the footpath in front of the house, and, strange to say, the vibration ceased; the asphalte was only half an inch thick with concrete underneath, showing that the vibrations must have travelled along the surface of the ground. I thought, and everybody else thought, that vibrations went bodily through the ground, but that asphalte on the footway did away with it entirely. This is a fact that may be of use to you. With regard to the remarks upon sewage arrangements, we must all be agreed upon this, that ventilation is most necessary, and we must all study the interests of our respective towns by the adoption of that system which is best suited to the locality. I move that the best thanks of the meeting be given to the President for his address.

Mr. Lewis Angell (Past President) had much pleasure in seconding Mr. Lynde's motion, and in doing so referred to the suggestion of the President, as one to which he (Mr. Angell) had previously called attention, viz. of the desirability of obtaining statistics for publication, which he thought would be of valuable assistance to Members, and he hoped the Members would co-operate in supplying them; without further remark, he had much pleasure in seconding the vote of thanks to the President for his excellent address.

The President: It is necessary that we should discuss the question as to where our next annual meeting shall be held. Perhaps some gentleman will make a proposition.

Mr. Pritchard (Warwick) suggested Bristol. That place was represented by Mr. Ashmead, who was a constant attendant at their meetings. If there is no great objection, I will propose that the next annual meeting be held there.

Mr. E. J. Purnell (Coventry) said Bristol was a large and important city, and as it was in the West, they could not do better than have their next meeting there.

The Hon. Secretary thought it would be good policy to open up a new district in the West.

Mr. Lynde was in favour of the suggestion.

The PRESIDENT said Bristol was a long distance off, and the only question was whether they should get a good attendance of Members.

The HON. SECRETARY said there was a good answer to that; they hardly ever held a meeting but that Bristol was represented.

On being put to the vote, the Members were unanimously in favour of the proposition.

The PRESIDENT said he intended, in the course of two or three months, to try and organize a new district in the West.

Appointment of Auditors.

Mr. Parry, of Reading, and Mr. Dunscombe, of Kingston-on-Thames, were appointed Auditors.

Publication of Proceedings.

The PRESIDENT said the next question he had to submit was the editing of the Proceedings. They were very much indebted to Mr. Angell, and if he would kindly undertake the work again, they should be very much obliged to him.

Mr. ANGELL said he should have great pleasure in doing so. He was most anxious that the Association should be a success, and having taken up this branch of the work in the beginning, he should be glad to continue it for the present, although very much otherwise engaged; not but that the work could be done as well or better by some other Member. The next volume would be somewhat thicker, and he asked the assistance of Members in expediting his work. Mr. Deacon had offered a variety of statistics on water supply and other subjects that would be a most valuable addition to their Proceedings, and save Members a great deal of trouble in obtaining the information which they were continually writing round for.

Some discussion ensued as to whether any assistance could be given to the editor, in the course of which Mr. Angell stated that the best assistance Members could render him would be by letting him have their papers and returning proofs without delay.

STREET TRAMWAYS.

By P. B. COGHLAN, C.E., Borough Surveyor, Sheffield.

There have been so many admirable Reports made on the subject of Tramways by several members of our Association, that I feel considerable hesitation in bringing it before you this morning.

But my apology is, that I find a great difference of opinion on several points on which it is our duty to advise the local authorities, and I think a discussion and interchange of ideas would be of great advantage to many of us in arriving at definite conclusions.

The subject naturally divides itself into *Working* and Construction.

I put working first, because although the local authorities are prohibited by the 19th Section of the Tramway Act, 1870, from working the Tramways (and I do not suppose that any alteration will be made as to this prohibition), yet the question of how they are to be worked is important in considering the first laying out of the lines to be authorized, and also affects the form to be adopted for construction.

Everything that affects the wear and tear of the Tramways, and their value as a "going" concern is important to the local authorities, inasmuch as a term is fixed (generally twenty-one years), at the end of which the Tramways may be purchased by the local authorities, or a fresh lease be granted for the working of them.

I may say at once that I am quite of opinion that, long before this period terminates, such improved machines will have been made that the consent of the local authorities and Parliament will be obtained for the working of the Tramways by power other than horse power, and that the Tramway Companies will find it to their interest to abandon, in most cases, the use of horses to carry out their traffic.

With reference to the *sort of traffic* for which the Tramway should be laid out and constructed—although by the 25th Section of the Tramway Act it is evident that Parliament intended the carrying of *heavy goods* on the Tramways—I cannot think that

(except in very rare cases) they will be used in this country for any but *passengers.*

Railway trucks would require a groove in the rail much deeper and wider than would be safe or convenient in the streets, or else they would require to be transported along the Tramways on a "bogie" or truck, which I don't think Tramway Companies would care to provide.

Goods traffic would require "sidings," depôts, and a staff and organization much in excess of what is required by passengers, so I think we may dismiss that from our consideration of the subject.

The *speed* allowed on the Tramways comes before us in the settling of the bye-laws.

This is under the control of the local authorities, and I think it is evident that, as a rule, in the streets or suburbs of a town, the speed should never exceed 10 miles an hour.

In laying out and constructing the Tramway, therefore, I should provide for passenger traffic only, carried on by either mechanical or horse power, at a speed not to exceed 10 miles an hour.

One of the most important advantages of the Tramways to the local authorities is the saving of the *maintenance of the streets,* as experience shows that the heavy traffic uses the portion of the road on which the rails are laid, in preference to the sides.

The Tramway Companies consequently save the street authorities the greater portion of the cost of maintenance of any street in which rails are laid.

I conclude, therefore, that the town authorities should always consult their own interest in having a *double* line laid in preference to a *single* line in any street sufficiently wide to allow the statutory width, 9 feet 6 inches, between the rail and the footpath. The wear and tear at the points, crossings, and curves required for the "sidings" or "passing places" of a single line, is very great; the waiting of the tramway cars at these places creates a nuisance, and an impediment to the traffic of the street.

All this is avoided by the laying out and constructing of *double* lines instead of single lines.

In narrow streets there would appear to be very great objection to allowing Tramways to be constructed at all, but I find that, even where double lines have been laid for a considerable distance in streets 18 and 20 feet wide, the balance of convenience is in favour of the Tramways. The convenience of the means of regular locomotion seems to outweigh, in the opinion of the residents, much of

the inconvenience and interference caused by the passage of the cars. But a good deal depends upon the sort of traffic in each such case, and upon the class of houses abutting on such a thoroughfare.

Where only a short length of the street is narrow, it is not always best to reduce the Tramway to a single line at that place. It is better either to make the "up" and "down" lines approach each other so that though the cars cannot pass each other at that place, the "up" and "down" lines are distinct, or else lay in cross-over roads at convenient intervals, so that, when necessary, the tramway car may take its wrong side of the road to pass any obstruction at that place.

It is very objectionable to have a "dead-end" or "terminus" in a street in the middle of a town, and, if possible, a loop should be made so as to avoid the inconvenience of reversing the horses or engine, or (if this is not possible) the tramway cars should run through from one suburb to another.

The question of *Working Power* will, I expect, come on immediately for the consideration of the local authorities, as, no doubt, any permission granted by Parliament will be subject to leave being granted by the local authorities to substitute any other power for horses.

At present the Locomotive Acts of 1861 and 1865 are prohibitory against the use of anything but horses on Tramways, but in the following cases, the use of power other than horses has been authorized, subject to the approval of the Board of Trade and the Local Authorities, viz.

The Wantage Tramway (Berkshire), and
The Vale of Clyde Tramway.

In 1871 an Act was passed authorizing the use of steam on Tramways in Ireland; and in 1872, on the withdrawal of Mr. Cawley's Bill for the same object in England, a Special Committee was appointed, which, after hearing evidence, made a long report, recommending that locomotives weighing less than 6 tons, making no sound from the blast, and consuming their own smoke, be permitted to travel at the ordinary speed of vehicles drawn by horses.

The Report further says, the Committee do not think it advisable to make any recommendation as to the employment of steam on Tramways, *but that they have received evidence, that the control and stoppage are at least equal to that possessed over ordinary tramway*

cars drawn by horses, while there need not be any noise greater than that produced by the movement of the car.

Since then, great improvements have been made, and several engines have been tried and used with more or less success.

The most promising that have been tried in this country are that of Mr. Hughes, of Loughboro', near Leicester, and that of Messrs. Merryweather, of London. The former is noiseless and emits no steam (which is condensed) and the tank must be emptied at the end of each journey. The weight is about 6 *tons*, on 4-feet wheel base.

It is not satisfactory, however, to see the driver on the top, in a position in which (although it may be best for seeing the road) he cannot see the water-gauge, so that there is risk of the water getting too low on a gradient of 1 in 20 or 30 when the engine is considerably tilted.

But this, and other objections which showed themselves in its experimental working on the Tramways through Leicester, can, I think, be got over without much difficulty.

Merryweather's engine is much lighter, and appears to be all that can be desired, with the important exception that the steam escapes in a way that is objectionable in this country.

In Paris this is not considered such an objection, and several are at work on the Street Tramways there, and, I have heard give satisfaction.

Other steam-engines have been tried on Tramways at various times, such as Perkins's engine (tried on the Brussels Tramway), and Downes's engine (tried at Birkenhead), but I have not heard that the results have been satisfactory.

The steam car, built by the late Mr. Grantham, and tried several times on the Tramway in Vauxhall Bridge Road has been modified and tried at Birkenhead, but I cannot think it will ever suit the peculiar exigencies of Tramway traffic to have the steam power in the car, and I don't think this combined tramway car and engine will be adopted, even if it were much more perfect than it now is.

Several other systems besides steam-engines have been tried for Tramway traffic. Probably the best as yet is that of Mekarski, which is propelled by compressed air of twenty-five atmospheres, stored in eight iron reservoirs from 12 to 16 inches in diameter, placed underneath the carriage and connected with each other.

The compressed air required for consumption passes through water heated to 340° Fahr., contained in a tank at one end of the

car, and drives a pair of cylinders having expansion and reversing gear.

An engine, also on a system of compressed air, is that of Moncrieff, tried at Glasgow; and Major Beaumont is working in the same direction.

All these, of course, require a stationary engine to fill the cylinders to be used for each journey, and though it is possible they may supersede steam, I should not expect to see animal power abandoned so soon if it were not for the improvements made in such engines as Hughes' or Merryweather's.

With regard to the economical question between horse power and steam (which only affects corporations so far as it shows what efforts will be made to obtain authority to make the substitution), I may mention that on an average it takes ten horses to work each tramway car holding thirty-six passengers.

This entails a capital expenditure of, say, 450*l*. for horses and harness, and about 200*l*. for stabling, &c., so that the first cost of the engines and necessary sheds and fitting shops would be about the same as for horses, &c.

The cost of these horses' keep, shoeing, &c., and depreciation or renewal, would not be much less than between 600*l*. and 700*l*. a year, and it is evident that this is more than double the cost of an engine capable of doing, on an average, the same constant work of, say, fourteen hours a day.

But the question of what it will cost to keep one of these engines in repair, with all the knocking about caused by constant stoppages, and the sharp curves, and points, and crossings, is one that cannot be well estimated.

It is evident, however, that the introduction of steam on Tramways will lead to a much greater extension of Tramways along suburban and country roads than is possible where animal power only is allowed.

I now come to the *Second Branch* of the subject, viz. the *Construction* of Tramways.

The introduction of steam power will, in my opinion, give the *coup de grace* to the system of using longitudinal sleepers for the rails.

It might be said that this is contrary to our experience on railway permanent way, but I think it is not so.

In railway permanent way the block or rigid system was admirably adapted to the traffic expected at the time.

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It was only the greater speed of 20 or 40 miles an hour that showed the necessity for a more elastic road.

The jumping and hammering caused by such speeds shook the rolling stock to pieces on a perfectly rigid road, but when the speed is limited to 10 or 15 miles an hour, there is no such vertical motion in the carriage, except when the rails are out of level, and except at the joint of the rail.

A perfectly rigid bearing is best for the Tramway traffic, which does not exceed 10 or 15 miles an hour.

There is no doubt, however, that with steam-engines the average speed will be increased, and the joints of the rails laid upon longitudinal sleepers will give way much quicker than they are now seen to give way on the Tramways laid on timber.

I don't know that any system of permanent way is quite satisfactory even on railways; and the same remark applies much more forcibly to Tramways.

In the timber system, as laid in London, Liverpool, Middlesboro', Dublin, and other places (including part of the Leeds Tramways), I think the construction is unsatisfactory, because the road is elastic, and though there are iron plates under the rails at the joints, a depression of the rail, and a jolt of the car, is generally to be found there, and this would be worse with an increased speed. Besides, I don't think the longitudinal sleeper properly holds the side fastenings generally used to clamp the rails to the sleeper.

The alternate wet and dry so near the surface of the road must have a prejudicial effect on the timber, and particularly at the curves, where the timber has to receive vertical cuts, about an inch or two in depth, in order to bend it round to correspond with the required curvation of the rail.

If cross timbers could be used I should think a satisfactory Tramway might be constructed with wood, but so long as we require the surface of the road to be paved, a difficulty will arise on account of the impossibility of bedding the paving-stones satisfactorily where the cross timbers occur.

Mr. Deacon, Borough Engineer, Liverpool, has designed a Tramway which he considers specially adapted for towns such as Liverpool, in which the ordinary traffic is very heavy.

The advantages claimed by Mr. Deacon are, that a uniform bearing is secured for both pavement and rails by forming a Portland cement concrete foundation *beneath the whole street*. The sleepers

(which are creosoted to the heart) rest upon the smooth surface of the concrete.

The rail is of steel, and trough-shaped, and weighs rather more than 60 lb. to the yard, though the width is only 3¼ inches, the usual width being 4 or 4½ inches.

The depth of the flange, and consequent transverse strength, are therefore exceptionally great. The top of the sleeper is formed to fit the trough-shaped under side exactly.

One of the objects sought has been to connect the rail with the under side of the concrete foundation, in such a manner that, while full advantage is taken of the rigidity of that foundation, a slight elasticity is secured by the presence of the timber sleeper.

With this end in view, a cast-iron washer is bedded in the lower part of the concrete, and from this washer a bolt is brought up 2½ inches above the concrete, and screwed with a right-handed thread, and the sleeper, having first been drilled vertically, so as to admit this bolt, is placed in position. A second bolt, having an eye at its upper end, and being screwed with a left-handed thread, is connected with a lower bolt by a large right-handed nut.

Through the side flanges of the rail two opposite holes are drilled, and the eye of the upper bolt having been placed between them, a three-quarter-inch pin is inserted to connect them. By screwing up the nut, engaging the lower right-handed and the upper left-handed bolts, the rail is drawn down to its position, and holds the timber sleeper, which acts merely as a packing piece, in position between the rail and the concrete foundation. These fastenings are placed at every 3 feet.

The second object claimed was greater uniformity of the surface of the rails and adjoining sets.

The whole of the sets, with the exception of those immediately adjoining the rails, are laid upon half an inch of sand.

The sets next to the rail are carefully picked, and, if necessary, dressed, and are alternate wholes and halves.

The two extreme ends of the base of each rest upon the concrete.

The stability of the whole pavement is further insured; and it is expected that the surface water will be prevented from penetrating to the sand, or to the sleepers, by filling the joints with a bituminous composition.

With the object, on the one hand, of obtaining a larger tread for the tram wheels, and, on the other, of reducing the inconvenience to

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ordinary traffic, inseparable from the existence of a broad iron rail, the groove and wheel flange is placed in the middle, and thus while the tread and life of the wheel are increased, the width of the rail is as stated reduced to 3¾ inches.

I consider Mr. Deacon's system to be very ingenious, though I don't think a timber sleeper 3¼ inches wide, even though it be 6 or 7 inches deep, can possibly make a permanent work under ordinary circumstances, but it remains to be seen what influence the bolting down of the sleeper to the concrete at every 3 feet will have.

It would, no doubt, cost as much to tighten up these fastenings as it would to put in new fastenings on the ordinary system.

The fastenings would cost more, but the necessity for cross sleepers is removed.

I have formed a very favourable opinion of the plan recently submitted by Mr. Souttar to the Manchester Corporation.

This may be described as a Tramway laid with steel rails, fastened by side fasteners to a continuous timber sleeper, and this laid upon cross sleepers embedded in the Portland cement concrete.

Considerable improvements, however, have been made in the rail fastenings and sleeper, as ordinarily used in this system.

The objection to all side fasteners is, that they keep the paving-stones away from the rail, thus leaving between the stone and the rail a hole or interstice, and, as these fasteners are very frequent (there being 14,000 of them in a mile of double way), it is evident that these holes must be a great nuisance.

This difficulty, as regards the fastener, is met by a slight modification of the rail. The flanges are brought in three-eighths of an inch, exactly the thickness of the clips, and by gouging out a small piece of the longitudinal sleeper, the fastener is driven in flush with the sleeper and the side of the rail, and thus the paving-stones can be got dead up to the rail.

The same improvement in the rail meets the difficulty as regards the bracketing of the *cross* sleeper to the *longitudinal.*

Instead of using *cast-iron* brackets, *bent wrought-iron,* five-sixteenths of an inch thick, spiked in countersunk holes, are used, so that the bracket is fastened, without leaving any projection whatever.

Cross sleepers, narrow on the top, and widening towards the bottom, are proposed, which is expected to prevent the constant

vibration now so frequently complained of on roads constructed on this principle but in the ordinary way.

I now come to the various systems of permanent way for Tramways, in which all the parts are of iron.

Some of these have longitudinal iron bearings, such as Dowson's, used at Madras, and Livesay's, used at Buenos Ayres, in which, I think, among other objections, the longitudinal sleeper has not sufficient bearing on the foundation; and a recent invention of a Mr. Barker, which is the best of this class.

This is on the continuous bearing principle, and may be described as a cast-iron trough turned over, and the bottom of the trough, being the upper surface when laid, formed so as to receive a rail.

I am afraid the fastening proposed, namely, an iron key through the web of the rail and the cast iron, is not quite satisfactory.

I think also that the lip of this trough, half an inch thick, which forms the foot as laid, is liable to be broken by the paving-stones when rammed close to the rails, and then we have the objection to all longitudinal bearers of cast iron, namely, the number of joints and consequent fastenings, and the difficulty that arises in the slightest deviation of the rails from a straight line, consequent on the curvature of the road, or route of the Tramway, turn-outs, &c.

Of other systems of iron permanent way we have that of Cockburn Muir, used at Monte Video; Nieman's, laid, I am told, in part of Vienna; and Kincaid's, which has been very much used in this country, having been laid on the Leeds, Sheffield, Bristol, Hull and Dewsbury, and Batley Tramways.

In Leeds it is laid side by side with the portion of the Tramway laid on longitudinal wooden sleepers, and shows great economy in cost of maintenance over the wooden system.

Kincaid's system, as first laid at Sheffield four years ago, was fastened by means of spikes passed vertically through the rail into the wooden plug, inserted in the cast-iron chair, but this was found to be a very bad style of fastening, as the tops of the spikes wear off, and there is difficulty in renewing them, but the objection can be obviated by the use of side fastenings driven into a wooden plug inserted horizontally into the chair and clamping down the rails.

The chairs are of such a form as give a good broad support for bearing on the concrete foundation, and at the same time allow the concrete to be bedded through and around the chair, so as to

make a true block road. The chair and concrete when laid form one solid block. This sort of support suits admirably, not only in the straight road, but also in all curves and points and crossings, and it is so easily repacked with concrete that I don't think any failure in the road ought to be allowed, even at the joints with high speeds.

The rails I am using now are of steel, but it may be a question whether, on steep gradients, they will give sufficient "bite" for Tramway cars descending.

The points generally used have been too short, and even lengthening them to 8 feet is not sufficient.

A point that can be acted upon by the driver of the car, as he approaches, so as to enable him to take whatever road he wishes, would be a great desideratum.

I believe several have been tried, but none are satisfactory.

Before concluding these discursive observations on a matter to which my attention has been directed, as Borough Surveyor of Sheffield, I should say that I have purposely omitted any remarks on an important branch of the subject, in which municipal officers have to advise their respective corporations, viz. the terms on which the required consent of the local authorities should be given, before the Parliamentary sanction can be obtained.

I do not propose to give an opinion on this subject.

The Corporations of Sheffield and Bristol are, I believe, the only ones that have laid the Tramways at their own expense, and different circumstances as to time and place may affect the question in various ways. It is a fair subject for discussion, and involves many weighty considerations.

I wish only to say, that I think Tramways have proved to be a very important public convenience in the towns in which they have been laid; that the contributions to the rates and maintenance of the roads, made by the companies working the Tramways, are matters of importance to the local authorities, and I think it is in their interest generally to encourage the extension of these undertakings, not only in the laying of them down in the first instance, but by assisting the development of a more satisfactory and profitable mode of working.

DISCUSSION.

Mr. ANGELL (Past President) said he had been very much interested by the very intelligent manner in which the matters of detail had been discussed in Mr. Coghlan's paper, but he rose thus early to offer some remarks cutting right to the root of the matter. Are tramways in busy towns desirable or not? He hoped he should not be looked upon as one of the old school nor prejudiced if he said they were in most places an unmitigated evil, that was, to those who had to use the roads and drive over them; they were all very well for those who used the cars, but in a crowded neighbourhood like London and other large towns, they were a great monopoly and a great nuisance. His own trap had been damaged several times, and complaints and actions were numerous. No plan had yet been adopted by which the rails and the pitching were kept on the same level; sometimes the metals rose and sometimes the pitching sank, and at all times the road was in such a state, in and about London, that if the local authorities were responsible they would be indicted for a nuisance. He did not deny that some convenience was afforded by tramways to those who used them, but in his opinion a well-appointed omnibus would be better than tramway cars. The omnibuses at Manchester, for instance, were far superior to those in use in London; they travel quite as fast as the tramway cars, and he was of opinion that such a convenient and commodious omnibus was better suited to town traffic than the rigid tramway system, which monopolized the roads and inconvenienced and endangered all other traffic. As to steam tramways and 10 miles an hour referred to by Mr. Coghlan, he thought it was simply preposterous as applied to towns; 6 miles an hour was quite fast enough for such a car in towns, and they were limited by law to that speed in London. If a tram-car could get out of the way like any other vehicle it would be a different matter. Apart from engineering details, Members should consider the question whether in ordinary towns tramways were at all desirable. The city of London would not admit the tramways. Of course light tramways across country for connecting small towns and villages was a very different and a very desirable thing. Railway construction is costly, and auxiliary tramways develop the country, but in busy towns he could not but look upon tramways as an obstructive and dangerous monopoly of the public highway.

Mr. Lynde (Past President) said, in reference to the remark about omnibuses, that two of the Manchester 'busses were sent to the Exhibition in 1852, and they were all sent back as unsuitable to London.

Mr. Angell: Because they were so wide; the same objection applies to tram-cars in London.

Mr. Royle (Manchester) quite agreed with Mr. Angell that tramways were very useful for outlying districts, but not for the centre of towns.

Mr. Buckham (Ipswich) said he quite agreed with Mr. Angell, that tramways are an intolerable nuisance in towns, and his life had been jeopardised by them. In country districts they were very good for uniting one small place with another. With regard to the suggested speed of 10 miles an hour, that would be positively dangerous, and he considered that with improved vehicles and improved highways there would be no occasion whatever for tramways.

Mr. Monson (Acton) thought it would be very well to have tramways if they were hedged-in on either side with a plantation, with a road outside for ordinary traffic, but as at present constructed they were extremely dangerous and unpleasant. If they wanted to see a specimen of bad management of tramways they should go down to the Uxbridge Road. A gentleman thought he would try wood paving, but before it had been down long it proved a failure, and now the wood was being replaced with stones by degrees.

Mr. Hodson (Loughborough) said, while he allowed that tramways were a nuisance, he did not go so far as to say they were an "unmitigated" evil; they were undoubtedly a great benefit to the poorer classes, and enabled a large number of people to indulge in a ride who otherwise would be compelled to walk. As to speed, when tramway cars were driven by an engine, that was a very great benefit, and for this reason, that an engine could draw up in less time than a pair of horses. Horses could not be driven beyond a certain speed, but engines could be driven fast or slow. Another thing in favour of locomotive engines was, the driver had nothing in front of him, and thus he was enabled to see directly what was before him. If ever engines propelled by steam came into use for tramway traffic, he felt sure they would not be driven by skilled mechanics; the same data did not apply to engines worked on tramways that applied to engines on the ordinary railways; the distances were always short, and the skilled

mechanic must be at the end of the journey and not with the engine; so that the man who drove it would, in point of fact, have less to do than the man who drove a pair of horses. As to repairs—the repairs of a tramway engine would not exceed 100*l.* per year, extending over seven years. He had kept engines in the colliery districts, and had never found them to exceed that sum. As to speed, he did not think the road would be affected by this, if it were properly made. Having applied himself to this matter for some years, and having brought out a successful engine, he should be glad to answer any questions that might be put to him.

Mr. DEACON (Vice-President) said, with reference to the remark that tramways were an "unmitigated nuisance," it appeared to him that as hitherto laid they had been, if not actually unmitigated, at least very great nuisances. At the same time he thought it was the duty of the Association and of its individual Members to inquire whether the peculiarities which had raised the great outcry in many English towns against tramways could not, in a great measure, be removed. So far as the objections taken rose from the cars being confined to a particular line, and unable to deviate when a vehicle approached in an opposite direction, all that could be done in mitigation of the evil was to provide means for stopping the cars in as short a time as possible. But he had had most unhappy experience of the difficulties arising from the mere existence of tramway rails in public thoroughfares. The Liverpool tramways were among the first laid in this country; they were promoted by Americans, and therefore naturally enough partook of the rough-and-ready system well known in those American cities of whose traffic tramway cars form so large a part. Where the streets are usually all parallel, or at right angles to each other, and where little or no loss of time to ordinary vehicles results from avoiding tramway routes, it would be unreasonable to expect that systems which under such conditions had been found defective, would not prove far more so in the irregular, crowded, and comparatively narrow thoroughfares of a great English town. The Liverpool tramways have therefore been a very great nuisance; but they were constructed before English engineers had given much thought to the subject. Since that time the immense number of patents taken out for improvements in tramways indicated that the subject demanded, and was receiving, much attention, though he feared, as a rule, from persons who had little knowledge of street pavements, or of the true difficulties which beset the introduction of tramways into the older

thoroughfares of great towns. He had examined all these patents, and had seen most of the tramways in this country, and many of those on the Continent, but he had failed to find, either in practice or on paper, the realization of those conditions which the exigencies of heavy traffic demanded; and as he was about to reconstruct the Liverpool tramways, it became necessary for him to consider the question *ab initio*.

To him (Mr. Deacon) it appeared that the chief defects arose from insufficient transverse strength of the rail to resist vertical pressure, from the rail being insufficiently bound down to the foundation of the road, from the want of a rigid foundation common to the sleeper and carriage way, and to the careless manner in which the pavement immediately adjoining the rails was laid. He agreed with Mr. Coghlan that the principle of rigidity in connection with tramways was more practicable than in railway work. Mr. Coghlan, however, had referred only to the absence of speed as rendering rigid tramways possible, but there was another element, viz. weight, which must have due consideration. The weight on each wheel of a locomotive was often from 5 to 7 tons, but upon each wheel of a loaded tramway car it was only about $1\frac{1}{4}$ ton, while upon each wheel of Merryweather's tramway engine it was only $\frac{3}{4}$ of a ton. If therefore the mere tramway traffic were considered, it was quite possible that absolute rigidity would be desirable. But in such a town as Liverpool, the wear and tear of the rails due to the tramway cars was very small in comparison with that caused by the ordinary traffic. They had had in Liverpool, for example, four-wheeled carriages bearing marine boilers with a load on each wheel of 14 to 15 tons, and there were loads of all weights, from this down to the ordinary Liverpool-lorry loads of $1\frac{1}{2}$ or 2 tons per wheel, all of them more calculated to disturb the rail than the tramway car, and the question therefore arose whether the principle of absolute rigidity was suited to such loads. In the tramways which he had designed for Liverpool, and which were about to be substituted for the existing lines, he had endeavoured to adopt a medium course between the absolutely rigid line and the almost invariably loose rail spiked or screwed down to the timber sleeper. Mr. Coghlan had, so far as was possible without a plan, explained the arrangement. One of the most important points was the mode of paving close to the rails. The foundation of Portland cement concrete was common to the whole of the carriage way and to the sleepers. The width of each ordinary set was limited to 3 inches

and its length to 7 inches. The joints were made as narrow as was compatible with keeping line, and were filled with riddled gravel and asphalte. Between the sets and the even surface of the concrete there was a bed of sand ½ inch thick. Each set next to the rail was however specially formed, so that without the bed of sand the two ends of its underside rested upon the concrete, the whole width of the upper edge next the rail touched and was about ⅛ inch above the rail, and the sets touched each other at the upper part of the transverse joints for an inch or two from the rail. Great care was taken with this work, and not only were the sets next the rail perfectly stable, but the greatest possible bearing surface of stone was ensured, and the formation of the well-known rut close to the rail retarded. Furthermore, it was easy to replace these sets with others similarly joined, and the extra cost was insignificant. The short lengths already laid in Liverpool had proved the feasibleness and advantages of the system.

With respect to Mr. Coghlan's remark to the effect that certain tramways of which he spoke the joints of the rails would not stand even if iron plate were placed beneath them, he thought that, looking back to the history of railways in this country, a lesson might be learnt with respect to the joint difficulty on tramways. Nearly half a century ago the rigid system of laying permanent way was first adopted. It was soon found to be a mistake in all railways with transverse sleepers—an extra heavy chair having to be placed under the joint. On this anvil the ends of the rails were continually being flattened, and the passage of each wheel over such a joint was marked by a most unpleasant jump. Almost innumerable expedients were adopted to obviate this, and only after the experience of twenty-five years was the now universally accepted fact discovered, that in order to avoid the difficulty, not only must the joint not be placed upon an exceptionally heavy chair, but it must actually be placed over a void. Yet in many tramways the mistake made in the first permanent ways had been revived. Plates under the joints of rails, he believed, did harm; and although he had adopted rails of a much greater transverse strength than any tramway rails yet laid, he had taken the precaution of hollowing the sleeper immediately under each joint, thus admitting a principle the very opposite of that which induces tramway engineers to render the joints more rigid than the other parts.

Mr. Kincane said the heavier the traffic and the more rigid the foundation, the better for bearing the enormous weights. The

speed of tramway cars affected more the upper surface; that was to say, the paving was more worn out by the high speed than by the heavy traffic. It was exceptional for 60 tons to be upon four wheels along a tramway. He quite agreed with Mr. Deacon that the joints ought to be hanging joints for high speeds; they had learned this from experience on railways, but where the speed was less than 15 miles an hour the joints should be separated. He did not know that he had anything more to say but to add his approbation of the excellent paper on this subject.

Mr. Lockwood (Brighton) could not agree with Mr. Angell that tramways were an "unmitigated" evil, although he admitted they were a nuisance, and some statistics showing their usefulness would be of benefit. He presumed these trams were considered to be useful in Liverpool, or the Corporation would not attempt to improve them. He considered railways a great nuisance notwithstanding their convenience, and preferred to travel by means of the old stage coach. His object in rising was to ask Mr. Coghlan if he could give some statistics to show the extent of the usefulness of tramways, how much they earn, &c., so as to give a complete answer to Mr. Angell's proposition.

Mr. Angell inquired if tramways were tolerated at Brighton?

Mr. Lockwood: No, the Corporation will not sanction them.

Mr. Lynde would like to ask Mr. Coghlan if he had any statistics showing the use of steel rails as against iron rails; whether they would be slippery for horses, or why they had not been introduced before.

Mr. Deacon: I am introducing them in Liverpool.

Mr. Lynde: I am anxious to lay steel ones if there is no objection on account of their slipperiness.

Mr. Kincane thought the price of steel had hitherto prohibited its use for tramways. Moreover, he believed the tramway companies themselves would object to steel, as much greater pressure would be required to bring up the cars.

Mr. Lynde: Would the friction be sufficient to prevent the slipping of the horses or wheels?

Mr. Deacon: The difference in the rails is not perceptible.

Mr. Lynde: Then how about horses?

Mr. Deacon: There is no difference at all between polished steel and polished iron—one was as slippery as the other.

Mr. Box wished to know if Mr. Coghlan had made any trial to ascertain how soon cars going at various velocities might be

stopped. A train moving at 10 miles an hour may be stopped in 10 yards; and as the friction must be greater on tramways than on railways, he thought the cars could be stopped in shorter distances.

Mr. ANGELL asked the gentleman who had spoken of the use of steam engines on tramways, if these machines could be worked quietly, and without frightening horses?

Mr. HUGHES replied that from these engines there was no steam nor smoke, and the noise was less than that when the horses were in use; horses were very little frightened now, but if the steam engine for tramways was adopted, it should be entirely and not partially. As to steel being used for rails, it was very difficult now to know in travelling which was steel and which was iron.

Mr. LYNDE said when on a visit to Birkenhead he rode on a steam tramway, and going at a speed of 14 miles an hour the tram was stopped at its own length. Excepting in the case of a farm horse, nothing approaching a fright occurred.

Mr. PRITCHARD (Warwick) rather liked the tramway, but when ascending or descending heavy grades steam power was much superior to horse power. A short time previously, while a tram was descending Snow Hill, Birmingham, the horses became alarmed and ran away, and the velocity of the car was so great that they could not stop it, and it was broken to pieces; fortunately there were no persons inside, or the result would have been most disastrous, and it showed to his mind that steam was preferable to horse power.

The PRESIDENT said, in reference to steam engines, he had tried some experiments in the Southampton Docks, in order to see what was the shortest length in which an engine could be stopped, and had found that it could be brought up at its own length.

Mr. COGHLAN then replied: Mr. Angell might be very thankful that he was surveyor of such an aristocratic district where carriages were kept, but for such towns as Sheffield, with a population of 300,000, amongst whom were thousands of people who lived a long way from their work, tramways were a great public convenience, and certainly not any nuisance. He admitted it was not very pleasant to drive over tramways, but they must consider the thousands who could not drive. He had not prepared any statistics as were asked for. They used steel rails in Sheffield, but the reason was that they took advantage of the market when there

was little or no difference between the cost of steel and iron rails. As to the projected speed of 10 miles an hour, there was some misapprehension upon that matter; he never contemplated that tramway cars should be drawn at that rate in crowded streets or towns; it was more a maximum for the suburbs, where 10 miles an hour would not be out of the question.

A cordial vote of thanks was given to Mr. Coghlan for his excellent paper.

Mr. Coghlan, in acknowledgment, said he hoped next year that he should be able to supply the statistics desired.

CONSTANT WATER SUPPLY.

By J. E. GREATOREX,
Borough Engineer, Portsmouth.

The question of a Constant Water Supply is of such immense importance to public communities in a sanitary point of view, that the author presumes it will not be out of place to refer briefly to a case directly bearing on that question in which he has recently been deeply interested.

The borough of Portsmouth is supplied with water by the Portsmouth Waterworks Company under the powers of various Acts of Parliament, dated 1857, 1861, 1868, and 1873 respectively; and the Waterworks Clauses Act, 1847, is also incorporated therewith.

The borough having been thoroughly sewered, the Sanitary Authority about four years ago commenced to put in force their compulsory powers for house drainage, and the conversion of privies into water-closets; until at the present time more than twelve thousand water-closets have been constructed under those powers.

During the progress of these works the author frequently urged the Sanitary Authority to require the Water Company to give a constant supply (it being now intermittent); and in accordance with those urgent representations the Authority gave notice to the Water Company to give such constant supply.

In accordance with such demand the Company applied to Parliament for powers to enable them to make regulations as to fittings for the prevention of waste, and obtained an Act in 1873 authorizing them to secure fittings for that purpose. That Act obtained the Royal Assent on 7th of July, 1873, and it enabled the Company in the event of disagreement between themselves and the Corporation, as the Sanitary Authority, to appoint an umpire to make regulations for such fittings. In this matter the parties did not agree, and by mutual consent an arbitrator was appointed in the person of Professor W. Pole, C.E., of Parliament Street, Westminster, whose decision was to be final.

The question of water fittings was taken into consideration in London in February last, and occupied many days. It was most

ably and eloquently argued on behalf of the Water Company by the Hon. A. Thesiger, Q.C., and Mr. Moore, and supported by the evidence of Messrs. Quick, as Engineers to the Company; Mr. Easton, jun.; Mr. Ayris, of Norwich; and their own Resident Engineer and Manager; and on behalf of the Corporation, as counsel, by Mr. Michael, with him Mr. Castle, and supported by the scientific evidence of F. J. Bramwell, Esq., C.E., F.R.S.; Mr. Berrey, the Manager of the Manchester Water-works; Mr. Geo. Jennings; Mr. Geo. Manwaring, Engineer to the Southampton Water-works; and the Author of this paper.

The final decision of Professor Pole as referee, in the shape of the regulations prescribed for the future guidance of the construction of water fittings in the borough, is appended hereto, and as this is the first instance of regulation fittings being applied to any provincial town under the powers of an arbitration, it is hoped that the information afforded herein and the code of regulations appended may be of some use hereafter to the Members of this Society.

Borough of Portsmouth Water Fittings Regulations.

The following are the Regulations approved and confirmed by the arbitrator to whom that matter was referred under the Borough of Portsmouth Water-works Act, 1873 :—

"1. No 'communication pipe' for the conveyance of water from the water-works of the Company into any premises shall be laid until after the point or place at which such 'communication pipe' is proposed to be brought into such premises, and the diameter of such 'communication pipe' shall have had the approval of the Company.

"2. No pipe, except such existing pipes as shall be sound and do not permit waste, or except when and as otherwise authorized by these regulations or by the Company, shall be laid, used, or fixed in or about any premises for the conveyance of or in connection with the water supplied by the Company, unless such pipe shall be of lead, of equal thickness throughout, and of at least the weight following, that is to say :—

Internal Diameter of Pipe in inches.		Weight of Pipe in lbs. per lineal yard.
$\frac{3}{8}$	.. ..	4 lbs.
$\frac{1}{2}$	.. ..	5 "
$\frac{5}{8}$	.. ..	6 "
$\frac{3}{4}$	.. ..	8 "
1	.. ..	11 "
$1\frac{1}{4}$	.. ..	16 "

Provided that where not buried in the ground, galvanized iron pipes of equal strength may be used at the option of the consumer.

"3. Whenever any communication pipe shall hereafter be connected with the pipes of the Company, and whenever any existing communication pipe or its connection shall hereafter be replaced or repaired, the connection of such communication pipe with the pipes of the Company shall be made by a screwed ferrule stopcock with union, and such ferrule stopcock shall be so made as to have a clear area of water way, equal to the internal sectional area of the communication pipe. Such ferrule stopcock shall be provided by the Company, and every such connection of every communication pipe with the pipes of the Company shall be made by the Company's workmen, the Company being paid in advance the cost of the stopcock and of and incident to the making of the connection.

"4. Every house supplied with water by the Company shall have its own separate communication pipe, except that in cases of groups of houses, the water rent for the whole of which is paid by the owner, the same may be supplied by one communication pipe for six houses in one block and adjoining each other, and except also in cases of courts of houses supplied by a stand pipe.

"5. Every joint in any lead communication pipe, or in any external lead pipe, or in any lead pipe below the level of the ground floor, and every joint connecting a draw tap or a stop tap with a lead pipe shall be of the kind called a 'plumbing' or 'wiped joint,' except such existing joints as shall be sound and do not permit waste.

"6. No pipe should be used for the conveyance of, or in connection with, water supplied by the Company which is laid or fixed through, in, or into any drain, ashpit, sink, or manure hole, or through, in, or into any other place where the water conveyed through such pipe may be liable to become fouled, without the consent (in writing) of the Company, and then only upon such conditions, and with such pipe or pipes, as shall be approved by the Company; and any existing pipe laid or fixed as aforesaid shall be removed unless such consent be obtained.

"7. Every pipe hereafter laid, altered, or re-laid for the conveyance of, or in connection with, the water supplied by the Company shall, when laid in open ground, be at least two feet below the surface, and shall in every situation be properly protected against the effects of frost.

"8. No pipe for the conveyance of, or in connection with, water supplied by the Company shall communicate with any cistern, butt, or other receptacle used or intended to be used for rain water, and any such communication if already existing shall be removed.

"9. Every 'communication pipe,' whether existing or future, shall, if required by the Company, but at their cost, have inserted in it at its point of entrance into any premises, and if desired by the consumer, but at his cost, also within such premises, a stop valve of the prescribed kind, having an area of water way equal to the internal sectional area of the communication pipe, and if placed in the ground, such stop valve shall be protected by a proper cover and guard box.

"10. Every existing or future cistern shall at all times be made and maintained water tight, and shall be provided with a ball tap of the prescribed kind for the inlet of water, and shall be properly covered and placed in such position as to admit of convenient and thorough inspection and cleansing.

"11. Every cistern, whether existing or future, shall be provided with an efficient 'warning pipe,' the materials, size, and height of which shall be at the option of the consumer. No overflow or waste pipe other than a 'warning pipe' shall be made or attached to any cistern, and every overflow or waste pipe attached to any cistern shall, within one month after these regulations shall come into operation, be removed, or be converted into a 'warning pipe;' and if, within one calendar month next after the Company shall have given the owner or occupier of, or left upon, the premises in which such cistern is situate, a notice in writing requiring such overflow or waste pipe to be removed or converted into a warning pipe, the said notice shall not be complied with, the Company shall be at liberty to cut off the supply to such premises.

"12. Every warning pipe attached to a water-closet cistern shall be placed in such a situation *outside* the premises containing the cistern as will admit of the discharge of the water from such warning pipe being readily seen by the Company, and every other warning pipe shall be placed in such a situation as will admit of the discharge of the water from such warning pipe being readily seen by the officers of the Company; and the position of such warning pipe shall not be changed without seven days' previous notice to, and approval by, the Company. No overflow or waste pipe shall be allowed to be connected with any sewer or drain.

"13. No existing or future cistern buried or excavated in the

ground shall be used for the storage or reception of water supplied by the Company.

"14. No butt or other wooden receptacle without a proper metallic lining shall hereafter be used for the storage of water supplied by the Company for domestic purposes.

"15. No draw tap shall be used or fixed unless the same shall be of the prescribed kind, and any existing draw tap not of the prescribed kind shall be removed, provided always that any existing draw taps of the kind known as Lambert's diaphragm screw-down taps shall be allowed to remain in use, and shall be considered as prescribed fitting so long as they are sound and efficient, and do not cause waste, but in the event of their becoming unsound or inefficient, or causing waste, they shall be removed.

"16. Every draw tap in connection with any stand pipe or other apparatus outside any dwelling house in a court or other public place to supply a group or number of such dwelling houses shall be of the prescribed kind, and be protected as far as possible by a proper guard from injury by frost, theft, or mischief, and any draw tap not of the prescribed kind, or not so protected, shall be removed or altered so as to conform to this regulation.

"17. Every boiler, bath, water-closet, and urinal to which the water of the Company is laid on, shall be supplied from a cistern, and shall not have any direct communication with the pipes of the Company. And every such boiler, bath, water-closet, and urinal now existing and having such direct communication, shall be altered so as to conform to this regulation.

"18. Every water-closet to which water supplied by the Company is laid on, shall be served only through a service cistern; and every such water-closet now existing and not so served shall either be made to conform to this regulation, or shall have the water supply cut off from it, and shall be flushed down by hand.

"19. All valves, cocks, taps, or other fittings used in water-closets, with purpose of admitting water to the pans or basins of such closets, must be self-closing, and any such valves, cocks, taps, or other fittings now existing which are not self-closing shall be removed.

"20. In tenements not exceeding twenty pounds per annum, rateable value, every water-closet to which water supplied by the Company is laid on shall have a waste-preventing apparatus of the prescribed kind so constructed as not to be capable of discharging more than two gallons of water at a flush, and every such water

closet now existing, and not having such a waste-preventing apparatus, shall either be altered to conform to this regulation or shall have the water supply cut off from it, and shall be flushed down by hand.

"In tenements not exceeding twenty pounds per annum, rateable value, every water-closet to which water supplied by the Company shall be hereafter laid on, shall have a waste-preventing apparatus of the prescribed kind constructed as not to be capable of discharging more than two gallons at a flush. And every water-closet to which water supplied by the Company is at present laid on, and which at any time shall be unsound or inefficient, or shall waste water, shall be altered to conform to this regulation.

"21. Every down pipe for the discharge of water into the pan or basin of any water-closet hereafter put up, allowed, or removed, shall have an internal diameter of not less than one inch and a quarter, and, if of lead, shall weigh not less than nine pounds to every lineal yard.

"22. No pipe by which water is supplied by the Company to any water-closet shall communicate with any part of such water-closet, or with any apparatus connected therewith except the service cistern thereof, and any such pipe now existing shall be removed or altered so as to conform to this regulation.

"23. No bath supplied with water by the Company shall have any overflow waste pipe, except it be so arranged as to act as a warning pipe, and any existing bath having an overflow waste pipe not so arranged shall be altered so as to conform to this regulation.

"24. In every bath hereafter fitted or fixed, the outlet shall be distinct from and unconnected with the inlet, and the inlet of cold water must be placed so that the orifice shall be above the highest water level of the bath, and shall have a tap of the prescribed kind. The outlet of every bath shall be provided with a perfectly water-tight plug, valve, or cock, and any existing bath not provided with such plug, valve, or cock shall be altered so as to conform to this regulation.

"25. No plumber or other workman shall be allowed to do or perform any work connected with the supply of water, unless he shall have been admitted and enrolled by the Company as an authorized water-works plumber, and has engaged to conform to and comply with these regulations.

"Provided that the Company shall not refuse to enrol any plumber carrying on business within the water limits, who shall

have satisfied them in all respects as to his competency on his applying and engaging as aforesaid, unless his name shall have been already erased from the list of authorized plumbers.

"If at any time afterwards any such plumber wilfully infringes the said regulations, either by himself or his workmen, or refuses to communicate any needful and proper information required of him in regard to any work connected with the works of the Company done by him or his workmen, or under his superintendence, or upon his responsibility, his name shall be erased by the Company from the list of authorized plumbers, and may be forthwith advertised as so erased in some one or more local newspaper or newspapers.

"26. No alterations shall be made in any fittings in connection with the supply of water by the Company, without two days' notice at least, in writing, to the Company, and such altered fittings shall be in accordance with these regulations.

"27. The words 'prescribed kind' used in Regulation No. 9, shall mean a stop valve of a screw-down kind. The body to be strong, of hard brass, and provided with a proper stuffing-box; the valve to be loose, leather-faced, and not liable to turn on its seat.

"The words 'prescribed kind' used in Regulation No. 10, shall mean a ball-tap, constructed on the equilibrium principle, to be made strong, of hard brass, with gun-metal seating and spindle, with cup leather packing of the best quality. The ball to be made of copper.

"The words 'prescribed kind' used in Regulations Nos. 15 and 24, shall mean a draw-tap of a screw-down kind. The body to be strong, of hard brass, and provided with a proper stuffing-box. The valve to be loose, leather-faced, and not liable to turn on its seat.

"The words 'prescribed kind' used in Regulation No. 16, shall mean a draw-tap of a screw-down kind. The body to be strong, of gun-metal, of good quality, and provided with a proper stuffing-box. The valve to be loose, leather-faced, and not liable to turn on its seat. The spindle and stuffing-box to be also of gun-metal of good quality.

"The words 'prescribed kind,' used in Regulation No. 20, shall mean a service-cistern, fitted with a boot or division, such boot or division to be as high as the top of the cistern, and to be capable of containing not more than two gallons of water when filled up to within three inches of the top thereof. Every such service-cistern

shall have two proper alternating valves working on separate rods, and so arranged as to let down at each pull or lift of the said valves a quantity of water not exceeding the contents of such boot or division, and in any case not more than two gallons; and such cistern and valves shall be so arranged and contrived that water shall not be able to flow into and out of the boot or division at the same time. The valves shall be worked by brass rods at least three-sixteenths of an inch in diameter, and not by wires or chains. The rods to be fitted with pin nuts and brass couplings, and in the case of pan-closets, the connection between the seat gear and the cistern gear shall be made with wrought-iron rods of the best quality, at least one quarter of an inch diameter, and fitted at all joints with brass-couplings.

"Provided always that in lieu of the above prescribed fittings, the Company, by notice to be given to the Town Clerk, may permit as prescribed fittings the use of any other stop valve, draw tap, ball tap, or water-closet waste-preventing apparatus, which will in the opinion of the Company be equally efficient to prevent waste with those above described.

"28. Every person who shall wilfully violate or shall refuse or neglect to comply with, or wilfully or negligently do or cause to be done any act, matter, or thing in contravention of these regulations, or any part thereof, shall for every such offence be liable to a penalty in a sum not exceeding Five Pounds."

DISCUSSION.

The President invited discussion on Mr. Greatorex's paper.

Mr. Lynde: There is one thing in the paper, that parties should be compelled to line cisterns with metal; it does not say what metal.

Mr. Deacon said if the general subject of constant supply had been raised, he might have said something upon the paper. He had read a paper some time ago to this Association on the subject of constant supply; he would relate what had been done since that time. The waste-water meter system described in that paper was at the time in a very crude state. The history of the matter he would now give as shortly as possible. In 1871, when he first took charge of the Liverpool waterworks, a supply of eight to ten hours a day was given. The ordinary system of house-to-house inspection was in use, and the rate of supply per head per day gradually increasing, and as it had become perfectly clear that the first dry summer would bring a dearth of water, it was absolutely necessary to reduce the waste and obtain an additional supply. In a short time the number of inspectors was doubled, but it was still impracticable to increase the number of hours' supply, and they only just succeeded in avoiding an increase in the rate of supply per head per day. The Corporation had little power to check waste beyond that contained in the Waterworks Clauses Acts, and a Bill was therefore prepared based on the Acts of Sheffield, Manchester, and other places, by which power was sought to prescribe the nature in detail of all new fittings and pipes, and the work in connection therewith, and to interdict the use of any existing fittings and pipes which, in the judgment of the Corporation, might lead to waste. This Bill was framed shortly after the passing of the Municipal Borough Funds Act, and a poll of the ratepayers having been demanded, the measure was rejected by a majority of the few who voted. As no relief could therefore be obtained from Parliament, the only course left was to devise some means of bringing to light a larger proportion of those cases of actual waste with which the Corporation had power to deal under their existing Acts. With this object in view the present system was devised. It might shortly be described as follows:—On every service main supplying a district of 1000 to 3000 persons an instrument known as the waste-water meter was

placed. The instrument was beneath the footway and contained a drum, revolving once in twenty-four hours, upon that drum a ruled sheet of paper was readily placed, upon which, at the end of twenty-four hours, a diagram was drawn, showing for each and every minute the rate of flow through the main in gallons per hour. If water was being used the rate of flow was irregular, and an irregular line was the result; if, on the other hand, waste alone was taking place, the flow being evidently uniform produced a uniform horizontal line. During the night the line of waste was clearly visible. In Liverpool 200 waste-water meters controlled the whole supply, and gave unfailing information as to the waste going on in each district. Now, the first part of the economy of the system began here, for whereas in the ordinary system of house-to-house visitation all districts, whether good or bad, were visited; in the Liverpool system only those in which the greatest waste was at any given time taking place were selected. Each day the three worst districts were chosen, and the same evening at about 11 P.M. two inspectors visited each of them. Under the footway, and outside each house or block, there was a stopcock on the house service pipe. Commencing at the one end of the district, each inspector opened a stopcock lid, and using his turning bar after the manner of a stethoscope, he readily detected the flow of water if a considerable velocity existed; if he heard no sound he partly closed the stopcock, and having thus contracted the orifice he listened again. If he still heard no sound he proceeded to the next; but if, on the other hand, the flow of water were detected, the stopcock was at once closed, and at the closed stopcock the inspector listened again. If the sound still continued, evidence had been obtained of a leak in the main between the main and stopcock, or at the stopcock; if, however, the noise had ceased, the leak was clearly in the house, or between the stopcock and the house. It takes some time to explain all this, but in practice the whole operation is performed in a few seconds. In his rough note-book the inspector enters his report with the number of the house and the exact time at which he closed the stopcock.

It might readily occur to anyone as being exceedingly difficult, if not impracticable, to obtain inspectors who would perform a fair amount of work at night under such conditions and without supervision of any kind; but supervision of the most perfect kind existed; for at the instant of closing each stopcock, not only did the meter take a note of the time when the operation was per-

formed, but it recorded the volume of water by which the flow in the main had been thereby diminished. At six o'clock in the morning the inspectors met at the office, entered their reports in copying ink in books prepared for the purpose, and at nine o'clock copies of these reports were ready for the day inspectors, who visited those premises, and only those premises, which had been reported. Before five o'clock that evening the leaks had either been repaired or notices issued to the owners or tenants, and the day inspector had entered, opposite to the night reports, his report of the day visit. The same morning the superintendent had before him the night inspectors' books and the diagram showing him the exact value of their work. The whole endeavour had been to concentrate energy on those places in which it could produce useful results.

In 1873, ordinary house-to-house inspection was entirely abandoned, and would, he hoped, never again be resorted to; the result had been as follows:—

	Gallons per head per day.
In 1873 the supply was under intermittent service	24½
" " constant service	33½
Constant service was restored on 31st December, 1875, and in 1876 the supply was, under constant service, about	20

Not the slightest difficulty had been found in working the system in practice.*

Mr. Parry (Reading) asked if the 20 gallons per head included business as well as domestic purposes?

Mr. Deacon said the 20 gallons per head per day was the total, less manufacturing supplies sold by meter. But it must be borne in mind that trades were supplied largely by assessment, and not by meter. The supplies for hotels, public-houses, warehouses, offices, shops, and domestic purposes, including waste, was only 16 to 17 gallons, the difference being due to trades not measured by meter.

Mr. Parry said he felt interested in this question, as he was about to make some experiments with these meters; he had had some by him, but had not yet used them. He believed that in large manufacturing towns a great saving might be effected; at Reading with constant supply the consumption was about 32½ gallons per head.

* For full information on this subject, see a paper on the "Systems of Constant and Intermittent Water Supply and the Prevention of Waste," in the 'Proceedings of the Institution of Civil Engineers,' vol. xlii. part iv.

Mr. Pritchard said to him this subject was most interesting at the present time; he had carefully followed Mr. Deacon in his figures, and had concluded that the subject demanded the earnest attention not only of that Association, but of all who were engaged in the construction of works. His own opinion was that the great bulk of the water was waste; in fact, he had received a return from Dublin, and out of a consumption of 42 gallons per head per day, it was estimated that fully half of it was wasted; at Warwick, out of a consumption of 40 gallons per day, he was satisfied that two-thirds were wasted. With regard to the meter system, he was of the same opinion now as at the onset, that it was a most accurate way of testing the quantity of water used and that wasted. From the returns to which he had before alluded, he found that some towns varied from 72 gallons to 10 gallons per head per day constant supply; in Greenwich it was 72; Glasgow, something like 50; whereas other towns of inconsiderable size were as low down as 15. This variation clearly proved that the subject was one requiring the utmost attention.

Mr. Deacon said with respect to Mr. Parry's question, he had given 20 and 17 gallons; but they must understand that although constant service was restored in Liverpool, it was only restored on the last day of last year; there was nevertheless an astonishing difference in the districts.

Mr. Parry said he knew there was yet a great deal to be discovered in the way of waste.

A Member asked what interval of time there was between the two diagrams.

Mr. Deacon said he saw directly what the question aimed at, and he should say that on the average it would take two months to obtain the full benefit of night inspection.

The President said they ought to be very much obliged to Mr. Deacon for the valuable information he had given them. He recollected visiting Liverpool when this meter was first shown to the Members of the Association, and he was quite sure the question of waste was not taken up so much as it ought to be. They had had different discussions on the question of the water supply, but he was convinced that if proper attention were given to the subject of waste, the existing source of supply would in many cases be much improved. He had often thought that it would be practicable to apply a meter to every house in the same way that the gas was managed; there was this objection, that there would not

be sufficient water to flush the sewers, but the sewers did not require so much water as many persons imagined they did; moreover, waste did not do it. He remembered that during the cholera epidemic in his borough the medical officer of health gave orders for the water taps to be left open throughout the night for the purpose of flushing the sewers, and of course the consumption went up enormously; in his opinion the best mode for flushing the sewers was to throw down a pailful of water every now and then. In the regulations just read by the Secretary, it was recommended that one pipe should be allowed for six houses; that ought not to be allowed. It was only the other day that he heard of a case in which three houses belonging to one owner were supplied with one pipe; one of the houses changed hands, and that house was inadequately supplied in consequence of its being at a higher level and farther off the main than the other two. The result of his experience was that every house ought to have a separate and distinct supply. As regarded the suggestion that the waterworks companies should have their own plumbers, he quite agreed that if efficient workmen were invariably employed the waste would be very considerably reduced. He thought they were very much indebted to Mr. Deacon, and he hoped that his meters would be introduced all over the kingdom.

STREET PAVEMENTS AS ADOPTED IN THE CITY OF MANCHESTER.

By H. ROYLE, Southern District Surveyor, Manchester.

At the second annual meeting of the Association at Manchester last year, the President briefly alluded to the street pavements of Manchester, and regretted that no paper had been prepared respecting them. I therefore now offer to the Association the following remarks on the subject.

The subject is one of great interest to members of this Association, as well as to the ratepayers of the various localities we represent; and as different modes of executing these works are adopted in different towns, an interchange of opinions and practice cannot but be of advantage. It is not only of great importance that we should be conversant with the local materials at our command, but our knowledge should extend to the best paving material that can be brought to us from long distances.

The generally admired condition of the streets in the city of Manchester is, to a very great extent, due to the use of asphalte between the joints of the stones, which not only secures the foundation from becoming saturated with moisture, but also very much facilitates the cleansing of the surface; it is also in a great measure to be attributed to the use of sets made from trap rock and syenite granite, the hornblende in syenites being somewhat harder than mica in ordinary granite, is much more durable; the Irish set, for example, which contains little or no hornblende, does not wear so well as those of the Welsh granite, which has more hornblende in its composition.

In this paper I shall disregard our macadamized surfaces, for they are graduully being replaced with granite sets. Their existence in such places as Manchester and other large towns is an expensive nuisance, the cost of sweeping and watering alone is enormously more than the cost of cleansing granite set paving; for instance, in the spring of 1870, in ascertaining the cost of

sweeping Chester Road in my district, which had at that time an area of 10,000 square yards of macadam and an equal area of granite pavement, the condition of each surface being uniform throughout, the cost of the former was 5*s.* 2½*d.* per 1000 square yards, against 9¼*d.* per 1000 yards for granite, or as seven to one nearly, and would average five to one throughout the year.

In laying before you the various descriptions of the pavements in the city of Manchester, I will commence by remarking, that the older pavements consisted of boulder stones, brought from the sea coasts of Wales, Westmoreland, and Cumberland. Their importation was discontinued some twenty-five years ago, but there is yet a considerable area of such pavement in existence in various parts of the city, more especially in the older and little used streets in the outskirts, which is now rapidly being replaced with granite sets. The old boulders taken up being finely broken, form an excellent racking between the sets previously to asphalting.

The foundations of our pavements are composed of cinders and other hard material, and seldom exceed 15 inches in depth, including 3 inches of gravel in immediate contact with the sets; the traffic is turned over this foundation until it becomes solid, and the temporary gravel surface is renewed from time to time as may be requisite; such foundations give every satisfaction, and we have had no reason to use concrete, which for many reasons is objectionable.

The principal thoroughfares are paved with granite or trap rock sets, the minor streets, of lighter traffic, are paved with millstone grit sets; these latter are obtained from the mountainous districts of Lancashire and Derbyshire, some twenty miles distant; the granites and trap rocks are obtained principally from North Wales, and a few from Ireland and Shropshire. Streets paved with granite require to be kept well sanded or well watered to prevent slipperiness, because under certain states of the weather they become slippery and greasy; nevertheless, on the other hand, they are, on account of their economy in repairs, eminently suited to the ratepayer.

The introduction into Manchester of small granite sets was at the suggestion of our eminent townsman Sir Joseph Whitworth; this was many years ago, when our principal streets were paved with large square blocks.

Since the introduction of the sizes now in use the Corporation have gone on rapidly displacing the boulder stones.

By the introduction of asphalte, or pitch made from coal-tar, between the joints of the sets, on the suggestion of the late Mr. Ronchetti, a chemist of Manchester, the Manchester system has become known as the best in use, and has been adopted by many towns in the north of England.

The asphalte used is a composition of coal-tar, pitch, gas-tar, and creosote oil, in the proportion of about 1 cwt. of pitch to four gallons of tar and one gallon of creosote, the proportions varying somewhat according to the quality of the pitch; these ingredients are melted and boiled together from one to two hours, in purposely made boilers (see model); when ready, the melted fluid is poured into the interstices between the sets, which have previously been filled with clean small broken stones, or with washed gravel pebbles, the paving having been well beaten before the introduction of the asphalte: the roadway is then ready for traffic at once.

During the past ten years the quality of the pitch has very much deteriorated in value for paving purposes, by the removal through distillation of that essential ingredient which caused the asphalte to remain elastic and adhesive; this defect is partially remedied by adding gas-tar to the pitch while boiling; still we find the asphalte used in the older laid pavements to be much better than that now made, and though we continue to try experiments with varying success or failure, yet so long as gas-tar remains at such a commercial value for the manufacture of aniline and other dyes, I fear that our pavements will not last so long in such good condition as formerly: the most obvious remedy would be for the Corporation to prepare their own pitch from the tar produced at their own gas-works.

One of the great secrets in the success of our paving is the use of this asphalte in a pavement having a good foundation; the fact of it being impervious to moisture and so elastic that it will not crack renders it ever ready to accommodate itself to all temperatures; sometimes in the extreme heat of summer the asphalte rises out of the joints in the centre of the roadways and slowly flows towards the channels; but this rarely happens, and only when the asphalte has not been properly prepared.

To give practical illustration of the quality and durability of our Manchester paving, I have upon the table nine sets, which have been brought for your inspection, showing the difference in their wearing properties and their liability to become slippery.

The most useful sizes of sets we find to be 5, 6, and 7 inches deep, from 3 to 3¾ inches wide, and 5 to 7 inches long.

The largest and deepest stones are used in streets having the heaviest traffic. A few years ago a large quantity of 4-inch cube sets were used; these are now being replaced with the three sizes named, these cubes being unable to withstand the lateral strain upon them, especially in streets having considerable gradients.

The sets now submitted for your inspection are from the quarries of the Welsh Granite and Portnant Granite Companies respectively, near Carnarvon, the Syenite Granite Company, Portmadoc, the two quarries at Penmaenmawr, the two quarries at Clee Hills in Shropshire, and the quarry at Newry in Ireland. The prices from all these delivered in Manchester are nearly the same, and the cost of repaving an old street, not including foundation, nor crediting the old material, is for 6-inch sets 8*s*. 4*d*. a yard; labour, gravel, carting, and asphalting, 2*s*. 6*d*.; being a total of 10*s*. 10*d*. per square yard; the cost for labour is for work done in the long days, when the workmen make 54½ hours per week; should, however, the work be done in the winter months, the cost will not exceed 3*d*. per yard more, averaging 11*s*. per square yard all the year round.

I have marked upon the samples the number of years they have been down and the streets from which they have been taken, as follows, viz.:

No. 1.	Old Blue Penmaenmawr, from Princess Street	down 28	years.
„ 2.	Welsh Granite Company, from Chester Road	„ 16	„
„ 3.	Clee Hills, J. P. Shorthorn's Quarry, from Cross Street	„ 10	„
„ 4.	Penmaenmawr, Kneeshaw, Lupton and Co., from City Road	„ 8	„
„ 5.	Penmaenmawr, Brundrett and Whiteway, from Moss Lane	„ 4½	„
„ 6.	Port Madoc, Syenite Granite Company, from Stretford Road	„ 3	„
„ 7.	Clee Hills, T. Roberts' Quarry, from Great Jackson Street	„ 2¼	„
„ 8.	Port Nant Granite Company, from Great Jackson Street	„ 2¼	„
„ 9.	Irish Granite from Newry, from Pall Mall..	„ 3	„

It will be observed that the Irish granite and Port Madoc stones retain much the rougher surfaces, and their durability is not equal to any of the others mentioned; nevertheless, these rough-wearing sets are excellent stones, and are especially suitable for streets having considerable gradients.

The durability of these Welsh stones is beyond estimating; they may be said to be everlasting, for after twenty years' wear,

their ends only become rounded by traffic; these when re-cut are again used in streets of less importance.

I would caution you against the use of the old blue Penmaenmawr stone, numbered 1, as being an extremely slippery stone, and one which makes a dangerous pavement.

The repair and maintenance of our granite asphalted pavements varies in proportion to the amount of traffic, the centre of the city being the heaviest; but with confidence I can safely say, that taking the entire city, the average duration is about fourteen years before they require totally relaying, and a sinking fund of 3*d*. per yard per annum will provide for labour and material in perpetuity.

There is at present no wood pavement in Manchester, but the experiment has been tried on one or two occasions, and has not proved satisfactory.

One street only has been laid with Val-de-Travers asphalte, having an area of about a thousand square yards, which after two years' existence was replaced with granite sets: during seventeen days in the months of December and January, 1873–4, the number of horses which fell were 12 carriage and cab horses, 39 lurry horses, and 10 cart horses, being a total of 61, or a daily average of 3·59. No account was taken of the number of vehicles passing along this pavement, therefore the account is somewhat imperfect; nevertheless this surface was extremely dangerous, unless in exceptionally dry or wet weather, at other times when greasy it was dangerous, and unsuitable for our Manchester streets.

However valuable Wood, Val-de-Travers, Limmer, or such pavement may be on the Continent, or even in the south of England, there can be but little doubt that the practical surveyor will admit they are not suitable to the humid atmosphere of this district.

In conclusion, I trust that what I have laid before you in relation to our Manchester streets may enable you to profit in your respective spheres by our experience, which has been both long and extensive.

The PRESIDENT: Before Mr. Clarke reads his paper, perhaps Mr. Royle will say what has been the wear.

Mr. ROYLE: In Johnson Street the average is about 11,000 tons a day, and in Cross Street many thousand tons. In Pall Mall the traffic is not so much.

ON THE CONSTRUCTION AND MAINTENANCE OF PUBLIC HIGHWAYS.

By E. B. ELLICE-CLARK, Assoc. Inst. C.E., Borough Engineer, Derby.

The construction and maintenance of highways is a subject that must form at all times a most important work of Sanitary Authorities, not only because of the increased comfort to the community of well-kept roads, but because of the increased cost of locomotion and cleansing and discomfort of badly maintained roads. It is popularly supposed that the mere covering of a road with broken stone is sufficient to form a good and permanent highway; this being the view taken by a large number of those who have the control over roads, the consequence is that in many cases throughout the kingdom the roads are in a bad state of repair, and cost a larger amount annually than is necessary for cleansing and watering. Roads, too, are frequently maintained by Committees, who have but a slight and imperfect knowledge of what their duties are; and I take it to be the duty of every Surveyor of Highways not only to advise his Committee of the quantities of materials that are required to maintain these highways under their direction, but further to inform them of the best known means of maintaining the roads in a state of maximum efficiency at a minimum cost. Thus the Surveyor secures the valuable aid of disinterested persons living at all parts of the district, in supervising the repairs; and indeed, without a large and expensive staff with anything like a long mileage, town roads cannot be kept as they should be unless the Surveyor is thus assisted. I therefore propose in this paper, as briefly as possible, to point out the cardinal points to be observed in the construction and maintenance of roads in urban districts.

The direction of roads is usually determined by private capitalists, but it should, in my opinion, form the subject of legislative enactment, that all new roads should be laid out in certain directions, especially in rapidly increasing towns; for were a precon-

certed plan to be carried out piecemeal by owners of property, not only would a large amount of money be saved, but public convenience would be served in a much greater degree than it is at present, where every owner of property makes roads to suit the fancy of his Surveyor or himself, when he would only be too glad to follow out a plan which, in nine cases out of ten, would cost him no more money, become as available for his own purposes, and be of much greater convenience to the public at large. I am therefore strongly of opinion that where new roads are projected the Sanitary Authority should exercise their discretion not only as to the constructive portions of the roads, but also as to their direction, for we must not forget that all these new roads ultimately form part of that network of highways which is still the chief means of communication from one part of the district to the other.

The next thing to be considered is the gradients of roads. All roads should be as nearly level as possible. To illustrate this, I may cite the instance of Bridge Gate, in Derby. Suppose from its lowest point to the summit at King Street we had a perfectly level roadway instead of having a gradient of 1 in 32 as we have, every horse drawing a load would be able to draw one quarter more than it does now, and as we have 1268 carts passing up this street daily, one half carrying 1½ tons each, 238 more tons could be taken to and from the town with the same amount of horse hire each day. Then, again, roads with steep gradients cost fully one-third more to repair than flat roads. In the case of Bridge Gate it is three times more than London Road—a flat road having a considerable traffic, in Derby—consequently it is difficult to form an idea, without going into detail, of the increased cost to the community of steep roads, which should in all cases, where practicable, be avoided, and any extra expense in making urban roads level at the first outlay will fully repay the authorities by the ultimate diminished cost of cleansing and repairing, to say nothing of the saving to the community by the increased weight that can be drawn with the same amount of horse expenditure. One of the next important matters in forming roads is the cross section, i.e., the shape from kerb to kerb. The prevailing profile now adopted is that of an elliptical projection, high in the centre, and sloping gradually to the channels—a section which is in my opinion the reverse of what it should be for roads sufficiently wide for four vehicles to pass abreast; and no main roads should be made a less width than this. My objections to the existing section for wide

roads are, that if the road is made sufficiently flat for carriages to run easily over *all* parts of the roadway the gradient is not sufficient to carry away the water, which lies in the centre and renders the crown rotten. In suburban roads the traffic is nearly always in the centre, consequently they are worn down most unevenly; this is manifestly a wrong result, as roads should be of such sections as no preference would be shown to any portion of their surfaces.

The prevailing section of roadways comes about by Engineers following the footsteps of Telford, who constructed all his roads to the elliptical section; but the conditions existing in his time are most dissimilar to the conditions and exigencies of our day. Telford's roads were highways from city to city, having few vehicles running on them. The great objects then were not what they are now, to present over the entire area the hardest and least slippery surface, to give the firmest foothold to horses, and to stand the daily wear and tear of thousands of vehicles heavily laden, but to keep the roads dry and sufficiently hard in their centres to bear the traffic of a few vehicles, rarely exceeding a hundred daily; the elliptical section suited those times and requirements; vehicles rarely meeting, consequently the inconvenience arising from the steep sides of roads was not felt, nor was the centre worn away, as the traffic was trifling. My own opinion is that all main roads, first being made sufficiently wide for four vehicles to pass abreast, and where the traffic is considerable and the rainfall is such as to necessitate pitched channels and storm water sewers, the channels should be in the centre instead of at the sides, thus obviating the tendency of vehicles to slide down the sides towards the kerb. The slopes to the centre channels from the kerbs need only be very slight, especially where hard material is used to coat the surface, in which cases a maximum of 1 in 40 might be adopted. The advantages claimed for the section of road with the channel in the centre are—

1st. In the case of a macadamized road with gullies and pitched channels, half the cost of both these serious items would be saved.

2nd. The gullies need not be trapped, but be left open as sewer ventilators.*

3rd. Carriages would use all parts of the road surface except the channel, producing an uniform wear.

* See the Report of the Borough Engineer of Leeds.

4th. The "slop" which is now swept to the sides of the road, thrown up to the carts, frequently bespattering pedestrians, would be swept to the channel in the centre, and be the farthest possible distance attainable away from the foot-passengers and shops.

5th. In the case of a crowded thoroughfare, the channel would divide the up and down traffic without the aid of police, and in the case of streets of 60 feet wide and upwards, the public lamps should be placed in this channel, thus lighting the highway from the centre, which, in my judgment, is the proper and most effectual mode of lighting such thoroughfares, and to which I shall on a future occasion call your attention.

The objections that have been raised to this section of roadway are—

1st. "The carriages slide down towards each other, especially in frosty weather. 2nd. A large stream of water washes away the metal at the channel."

My answers to these are that the slope of the road to the centre will only be slight, just sufficient to carry away the water, and not sufficient to cause the tendency of vehicles to slide to the centre to have any foundation in practice.

The second objection is overcome in the case of sewered streets with frequent gullies, for the water disappears down these before it has assumed sufficient volume to become a stream having velocity enough to wash away the metal.

By placing the lamp posts* and gullies in the centre of the road the former might act as sewer ventilators, carrying the gases up the column and discharging them above the breathing area of pedestrians, thus enabling them to be diluted and dispersed. Again, every lamp column base might be formed into a street gully, and at intervals, where the width of the street would admit, entrances might be formed in conjunction with column and gully into the sewer, thus obviating the costly side entrances now in vogue.

I am quite aware that this section of roadway is contrary to all the practices and prejudices of Surveyors in this country; but I believe, if tried, we shall obtain better roads at less cost both in construction and maintenance, and a more effectual mode of ventilating our sewers, all objects of paramount importance to Sanitary Authorities.

The next important matter in connection with roads is the

* In the discussion which followed it will be seen the author abandoned the centre lamp-post idea.

nature of the materials of which they are formed and coated. The ordinary mode now in practice is to lay in a bottom of hard core, rammel, foundry cinder, or some such kind of material, to a depth varying from nine inches to one foot, without any uniformity as to size. The practice of the first roadmakers in the world, viz., the Romans, and also the great roadmakers at the commencement of the present century, was to lay courses of large sized stones by hand on the road bed to form a foundation, which, as a matter of fact, was the actual road; the next coating of broken stones being merely a covering to take the traffic wear, and prevent the road proper beneath from being worn into holes. The advantages of this method of forming a road are, that as it has to sustain great pressure from heavy loads and "violent percussion," it forms a solid foundation, which is necessary to resist these. In the case where the tyres of the wheels are narrow and the loads heavy, the modern system of roadmaking is most pernicious. Under the old system, this kind of traffic* is dealt with much more economically, as the weight is distributed over a much larger area, thus preventing clay and other soft material from "spewing" up when the road has become out of repair and soddened with wet.

Another great advantage of forming a rough pavement like the one I speak of, is that it forms a drain for the water, which finds its way through the top coating of broken stone, an especial advantage on a clayey soil. A road formed in this manner will cost but a little more than if formed by the prevailing mode, as stone of a much larger inferior quality and less costly character may be used; it will bear a much greater amount of weight; the bottom will not be influenced by the most severe frosts and rapid thaws; and a less quantity of broken stone may be used than if the bottom is of small stone or hard core thrown down at random. In addition, the covering of broken granite or other hard stone will last much longer on a foundation of this sort, and the expense of repairing and scavenging will be considerably less. Sir John Macneil, from actual experience, computes the saving by forming a road like this at least one-third the expense of repairs annually, and I believe this to be within the mark.

I should like to say a few words on the use of small round stones (boulders) used on outlying roads, and state my objections thereto. These small stones, unbroken, being pressed by vehicles against each other, find no 'bed' when they come into contact.

* Omnibuses, railway vans, &c.

By such pressure they move, and thus form hills and depressions on the surface; and the joints being large, gaping in fact when compared with those of cubical stones, a large portion of the exposed surface-joints becomes filled with horse dung and mud, which must give off an offensive effluvia and be prejudicial to health. The illustration of McAdam to a Parliamentary Committee, when explaining the advantages of using cubical instead of spherical stones, is conclusive: he had two basins, one filled with marbles of broken stone, the other with spherical stones, and requested the Members of the Committee to thrust their clenched hands into each basin. They thus had demonstrated to them that they could plunge their hands to the bottom of the latter basin with ease, and the marbles "spewed" up, while the greater the pressure in the other basin, the tighter and more compact were the contents; and thus it is on a larger scale with roads.

I have hitherto been speaking of suburban roads, where the traffic is not so great as to require paving on the surface. Let me now deal with roads where the nature of the traffic is such as precludes the use of a broken stone surface. Premising that it is difficult to determine where macadamising should end and pitching or paving commence; where it is cheaper to cover a road with small unfixed broken stone or pave the entire surface with fixed blocks; it would appear, at first glance, that that road which has the greatest number of vehicles passing over its surface should determine this, but I am of opinion that such is not the case. Bridge Gate has less traffic daily than the Wardwick,* the latter street having the disadvantage of being narrower, consequently the traffic is concentrated, and the amount of wear would thus appear to be much greater, but it is not so; therefore the mere enumeration of the vehicles passing a given point on a road will not enable us, without other considerations, to draw a hard and fast line when it is more economical to pave roads in preference to macadamising them. We must also take into account (*a*) the class of traffic, subdividing this into heavily weighted, spring, narrow tyred vehicles, and carriage traffic; (*b*) the gradient; (*c*) the nature of the bottom; (*d*) the width, and the height of the buildings. In three of these considerations (*a*, *b*, and *c*) the Wardwick has superior conditions to Bridge Gate; we thus see why the former is a more economical road to maintain than the latter; therefore, every street must be treated on its own merits.

* In Derby.

To ascertain whether it would be a saving to pave the streets,* I have endeavoured to obtain the cost of repairing and cleansing the same. I have left the watering out of the estimate, as I cannot obtain figures sufficiently reliable to enable me to produce them here, except in the general question of watering, which see, page 77. Taking Bridge Gate roadway, which is 458 yards in length, and covers an area of 2,931 square yards, the annual cost of cleaning is 80*l.* 10*s.*, or 6½*d.* per yard. The cost of maintenance is 219*l.* 16*s.* 6*d.*, or 1*s.* 6*d.* per square yard. To show the loss sustained by keeping the road in its present macadamised condition, I may state that Moorgate Street, London, with a daily traffic of 7,400 vehicles, costs 1*s.* 4½*d.* per square yard to pave and maintain; and I have given a table comparing the cost of some of the streets of Derby with those of paved streets in other towns, which will enable you to form an opinion as to the estimated saving to be effected by pitching. I have not, in this calculation, estimated the saving that will be effected to the community using the whole of these roads, but I will estimate it for Bridge Gate, as an indication of what it would be.

The traction on level roads has been ascertained to be nearly as follows:

Roadway asphalted	1·0
„ paved, dry, and in good condition	2·0 to 1·5
„ „ and in mediocre condition	2·5 „ 2·0
„ „ but covered with mud	2·7 „ 2·0
Macadam in good condition and dry	3·3 „ 2·5
„ wet	3·3
„ in mediocre condition	4·5
„ covered with dirt	5·5
„ with the stones loose	8·2 to 5·0

This is a low estimate. Some careful experiments give, taking the maximum load a horse can draw on a gravel road as a standard:

On a best broken stone road	3 times as much.
On a well-made pavement	4½ „
On the best stone trackways	11 „
On railways	18 „

Here we see that there is a loss of more than 100 per cent of motive power between macadam in a mediocre condition and a roadway paved and in good condition, and assuming that 951 tons are daily carried through Bridge Gate 300 days in the year, and the average friction is 1-20th of the weight, the cost of transporting this burden is 1,664*l.* per annum. If we reduce the

* Given in the Appendix.

traction by one half, as above, we reduce the cost of transport on this road to 832*l.*; but assuming this to be a theoretical supposition, and we take it at half, viz., 416*l.*, this would practically be the actual sum saved in horse hire alone, by having the street properly paved.

We now come to the question of cost of cleansing, &c. Taking the number of square yards of its area at 3000 in round numbers, we have ascertained that the cost of cleansing the street is 80*l.* 10*s.* per annum. From careful observation I have ascertained that four loads of mud or slop are removed from macadam per 1000 yards of surface to one load per 1000 yards of granite-paved surface, which is reduced to one-third of a load on a surface paved with wood.* I will, however, take the quantity at one-half, as we purpose to use granite as the material for paving this street hereafter; this will save 45*l.* 5*s.* for cleansing. This calculation does not include the carting of the slop to a shoot, which would bring the total up to 100*l.* a-year while macadamised, and the saving in cleansing if paved to 50*l.* a-year. The saving in maintenance will be this: the original cost per yard, including concrete, will be 13*s.*; the cost of maintenance I have estimated at 4*d.* per yard per annum; the life of the road I have estimated from authentic examples at 25 years. This gives us a total cost of a little over 10*d.* per yard per annum, or 125*l.* for the whole, as against 219*l.* 6*s.*, the present cost, thus effecting a saving of 94*l.* per annum; add this to the 416*l.* and the foregoing 50*l.*, and we effect a saving of no less than 560*l.* per annum to the community at large, to say nothing of the freedom from dust and the increased comfort to every person using and living in the road. I have, in Table IV., shown the annual amount of saving to the Sanitary Authority of Derby by having some of the principal streets paved, in the matter of expenses of cleaning and maintenance, though I have omitted the calculation of the saving in horse hire to the community, as the example of Bridge Gate is sufficient.

From careful observation I should say, all other things being equal, it is cheaper to pave a roadway having a traffic of one thousand vehicles per diem over its surface than to macadamise it, and this would be the minimum number to commence paving with. Under exceptional circumstances this might be deviated from.

We must now enquire and specifically lay down what are the requirements for such paved streets. The Engineer of Birming-

* Report of Borough Engineer of Birmingham, 1874.

ham has admirably set them forth in a recent Report to the Council of that Borough. He says: "They should be even-faced, firm, hard, as noiseless as possible, able to bear any burden, with sufficient foothold for horses, and capable of being easily cleansed, so as to diminish as much as possible the annoyance arising from mud and dust; the nearer these objects are attained, the less will be the wear and tear of the roads as well as of the vehicles; property and health will be less injured, and the comfort of pedestrians increased."

These, then, are the desiderata of Highway Authorities, and, as will be seen at a glance, most difficult of attainment. To obtain noiselessness and the least friction, the surface must be smooth; to obtain a firm foothold for horses, the surface must have a certain amount of roughness (I use the word in place of a better one which I cannot find, though it hardly expresses my meaning), so that two of the desiderata are inverse to each other, for as we decrease the noise and friction we increase the slipperiness. To endeavour to make these meet the material should be as hard as possible, providing it gives the requisite amount of roughness of surface by attrition.

You are aware that during the past few years various materials have been introduced to supersede stone for paving streets having large traffic and heavy burdens, and though the experience gained by the Engineers of London, Liverpool, Birmingham, and Bristol, and other large towns, is of much value, I think we may fairly say that the period of time over which their observations have extended in reference to asphaltes and wood, is insufficient to enable them to come to a final conclusion as to the merits of these respective materials. That this is so may be gathered from the very opposite opinions given, nearly all based upon short-timed observation or theories. As to the durability, cost, noiselessness, and slipperiness of materials for roads there should be no doubt whatever; but these can only be ascertained by actual observation, extending over a period of years, in streets with varying traffic as to number and nature of vehicles and weight of loads, and it would be unwise, most unwise, to reject a well-tried material for others, some of which have been pushed into the market without trial of any sort whatever. On the other hand, it would be unwise to expend large sums of money in laying stone pavements if there are other obtainable materials more suited to paving purposes. I will proceed to examine the qualities of paving material. If durability

and cheapness only had to be considered, so far as my observation goes, there can be no question as to the superiority of granite over all other materials used to pave streets with, more especially if laid so as to form a tram or trackway for the wheels of heavily laden vehicles to run along. And this opinion is shared by all those who have more lengthened experience of the requirements of busy streets; but these are only two of many considerations to be borne in mind: there are also safety to horses, noiselessness, easy traction, freedom from mud and dust; hence the attempts to supersede the use of granite as a paving material. Probably the desirability of decreasing the noise caused by the vibration of vehicles in business thoroughfares has had more influence than anything else in these attempts to supersede the hard granites, and we must bear in mind that however desirable a perfectly noiseless pavement may be, in some thoroughfares it is a question that we can afford to discard, if purchased at too high a cost, in some streets, where neither the occupations of the inhabitants nor the pedestrian traffic is such as to force this desideratum forcibly upon us.

So far as I can ascertain, wood blocks, squared like granite pitchers, appear to meet more of the requirements than any other of the newly introduced materials, if we are prepared to put on one side the question of cost altogether; though, on enquiry, I find a host of objections urged against its use, some of which are worthy of attention: the first being its permeability to wet, the separation of its fibres, and consequent absorption of "dung and putrescent matter," which are said to become "highly noxious." Again, it is urged that the blocks are separated by concussion, thus opening the joints and permitting the wet to reach the foundation; the wood thus, being constantly wet, in hot and dry weather gives off, in evaporation, very foul matters, which taint the atmosphere sufficiently to injure health. These are allegations difficult of refutation; indeed, by actual observation in some of the London streets, I am convinced the entire area of wood pavement is almost constantly saturated, and that it wears down very rapidly when compared with granite, under the narrow tyres of continuous omnibus and railway van traffic. How far the objections as to tainting the atmosphere are valid I must leave those more competent to judge to decide, and confine myself to its actual cost, durability, and general suitability as a paving material.

In Bristol, one, or a portion of one, of the main streets was laid

down, and eleven months after the Borough Engineer reported that:

"The general appearance and surfaces of these pavements continue up to present time in much the same condition as when laid, but I have caused portions of the Wine Street paving to be removed at either end of the street, in order to ascertain its state, and can find no perceptible difference in the same at either opening, there being no appearance of decay, and the wear of the surface of the blocks is scarcely perceptible, but at the Union Street end of Wine Street the surface water has percolated through the joints of the wood to the foundation; this has rendered the pavement at this end of the street less rigid, and the constant working by the passing of the traffic over it has caused several of the blocks to split or crack, and it is probable will necessitate the relaying of this end of the street before long."

Two years' experience enabled Mr. Ashmead to confirm his opinion as to the leakage of the joints destroying the pavement, for he says:

"Although nearly twelve months have now elapsed since my last report on this subject, the general appearance and surfaces of the pavements in Wine Street, Broad Street, and the Exchange, still continue in much the same condition, nor has the portions of Wine Street (re-laid by the Company) been much improved thereby, as the surface-water still finds its way through the joints, and a larger proportion of the blocks in this street are split or cracked, but the pavements of Broad Street and the Exchange appear to be wearing well, and are more rigid and firm, and free from the defects of the Wine Street pavement. This last paving has now been laid about twenty-three months, and Broad Street and the Exhange about seventeen months."

Writing personally to me, Mr. Ashmead says: "The wood will require repair in four or five years, but the comfort is so great that some people prefer paying for the luxury, but there is nothing like granite for durability and economy." How far we should be justified in laying down certain streets with a costly and luxurious article out of the general rates it is for the Council to determine.

The evidence of Mr. Deacon, C.E., the Engineer of Liverpool, is to the effect that the pavement laid in Bold Street, in September, 1874, has worn but little.

The Borough Surveyor of Birmingham says that wood "presents an even surface, affords good foot-hold for horses, is

pleasant for riding over, free from noise and mud, dust however rising rapidly; it is capable of being easily cleansed, but, like all other pavements, it is somewhat slippery in certain states of the weather."

I have made observations on the condition of the wood pavement in London; they are several, as will be seen from Appendix, Table V., and I have extracted from a recent publication descriptions of them:

Croskey's Wood Pavement.—Several plans of wood paving have been of late years proposed. One by Mr. Croskey was to manufacture cross grained planks of wood of any length, which being placed side by side, are forced together by pressure, so as to form a compact homogeneous surface of wood, which was to be laid upon concrete. This plan does not seem to have been tried, at least in this country.

Harrison's Wood Pavement.—This system consists of a concrete foundation, upon which strips of wood 2 in. by half-an-inch in thickness are laid. Wood blocks, 3 in. in breadth, are placed upon these wooden strips, and heated asphalte poured into the joints, which penetrates under and adheres firmly to the blocks.

Henson's Wood Pavement.—The main principle on which Mr. Henson proposes to construct his paving is placing *felt* on the bed and between the joints, thus giving, as he asserts, an elasticity to the road, and allowing by the felt jointing for the expansion and contraction of the blocks. He also varies the shape of the blocks; in one roadway they are bevelled on the top edges, in another at every fourth or fifth block, and in another a V groove is to be cut down the centre of the block, the object of this last being to prevent the surface-water from soaking down the joints to the foundation.

The Ligno-Mineral Wood Pavement, which is laid in Gracechurch, Fore, and Coleman Streets, possesses certain peculiarities, and differs from others in that it is mostly composed of hard wood, such as elm, oak, beech, or ash, which has been subjected by hydrocarburetted oils to a treatment termed mineralization. The blocks, which are 9 inches long, 3 inches wide, and 6 inches deep, are sawn at an angle of about 60 degrees, the object of this being to expose the fibre obliquely to the wearing face, and to distribute the weight of the traffic from the one block to those adjacent to it in the line of thrust. On the sides of the blocks near their bases, a groove is cut, which is filled with an asphaltic mastic (pitch and

tar) during the process of laying. The blocks are laid on a concrete foundation, the angle of each course being in an opposite direction to the previous one. The remainder of the joints to the surface are filled in with a grouting of lime and gravel.

Carey's Wood Pavement is perhaps that which can be most rapidly laid down and repaired, and is formed as follows, viz.: the blocks are cut 4 inches wide by 9 inches long, and to the depth of 5 inches or 6 inches according to traffic; these blocks are shaped with alternate convex and concave ends, and are laid on a bed of ballast or sand, averaging 2 inches; the joints, which have been left about ⅜ inch wide, are filled with a grout of lime and sand. The advantages claimed for this pavement are, that by the peculiar shaping of the blocks, they will not be shifted from their positions, and further, that the weight that may be put on each block is thus dispersed over an extended area.

Messrs. Mowlem and Co.'s method of laying wood paving is to form a foundation of concrete, varying in thickness according to the nature of the subsoil and the traffic; then to pave with blocks of yellow deal, 3 inches wide and 6 or 7 inches deep; the joints, which vary from ⅜ to ½ inch are filled in with sand and lias lime, and the surface is afterwards indurated by strewing it with shingle.

The Improved Wood Pavement is formed of two layers of one-inch boards laid transversely and longitudinally on the old road foundation, which is made up with sand or dry earth to the proper curvature; on these boards wood blocks are placed, the longitudinal joints being kept three quarters of an inch apart by a fillet (which is nailed to the flooring) and the heading joints butting. The joints from the fillet up to the surface of the road are filled in with fine ballast, run with a liquid tar, and caulked with a machine made for the purpose: the road is then strewn lightly with small gravel and is ready for use.

The principal advantage claimed for this system is that the flooring of planks forms an elastic foundation and tends to distribute the weight equally over the whole pavement, while the additional elasticity will lessen the wear of the blocks.

The Asphaltic Wood Pavement.—The mode of laying this system of wood paving is as follows, viz.: a concrete foundation, composed of blue lias lime and ballast in proportions of one part of lime to five or six parts of ballast, is laid to a thickness of 6 inches and to the correct curve of the road. Over this is laid a layer or

bed of mastic asphalte half an inch in thickness, upon which wood blocks are placed in transverse courses with the grain of the wood upwards, a space of half an inch (or more if desired) being left between each course. Into these spaces, or joints as they are more usually called, heated asphalte is poured to a depth of from 2 to $2\frac{1}{2}$ inches up the block. This method is better than most others, but the cross joints are all open and liable to let in water.

These are the pavements of wood, tried in London and elsewhere, and one cannot but be struck with the fact that only one attempt has been made in the Metropolis to preserve the timber chemically, by such processes as Kyan's, Burnett's, Renwick's, or Boucherie's.* In my inquiries I have only found another instance where any such attempt has been made, and that is at Sunderland. Here I find from a report of the Borough Surveyor, dated 17th December, 1875, that as far back as October, 1867, a strip 6 feet wide, was laid with creosoted Baltic red wood; a strip of 3 feet wide with creosoted beech; and a strip of 6 feet wide with uncreosoted oak; and it appears that after eight years, with a daily traffic of 1,300 vehicles, the total cost of repair was 101*l.*, which was equal to a cost of $6\frac{1}{2}d.$ per superficial yard. For the last five years, in those portions where the creosoted Baltic and beech, and uncreosoted oak were laid, no repairs have been necessary. The average vertical wear of the entire pavement has been $\frac{5}{8}$ of an inch, the Baltic has been $\frac{3}{8}$ of an inch, the beech $\frac{3}{8}$ of an inch, and the oak has not appreciably worn at all. The creosoted timbers are said to be harder than when first laid; the beech and oak are spoken of as being too hard and slippery. The surveyor says that the use of creosoted sets dispenses altogether with the cost of watering. This deduction is questionable, though the results are certainly the most favourable I have obtained, both as to the wear and cost of wood pavements.

The method of laying a wood pavement by having longitudinal and transverse boards beneath for a foundation, is, to my mind, a faulty one. In the first place, by personal observation, I have seen a heavily weighted vehicle produce a depression of an inch as it passed along the pavement, which sprang up to its original form as the burden left it. Again, the "elasticity," which is claimed to be an advantage, is, to my mind, the reverse. If the pavement

* Kyan saturates the blocks with a solution of bichloride of mercury; Burnett with a solution of chloride of zinc to be absorbed in a vacuum; Renwick boils the blocks in coal-tar; and Boucherie uses impure pyrolignite of iron.

sinks beneath the load it has to carry, it is like having a surface of india-rubber; with this depression an inclined plane of 1 in 7 is formed with a wheel 4 feet in diameter, and one-seventh of the load must be raised this inch, and this is continually going on with such a bottom. It is next to an impossible thing for the numerous joints in the area (a diameter about 18 inches under 3 tons) thus effected by each wheel to remain water tight, be they made with asphalte or pitch, and the water must pass through them on the planking below, which, sooner or later, must be rotted. These open joints in the end must wear the edge of the blocks round, a fact I noticed in Birmingham, on close examination, which caused a most unpleasant vibration as a light-springed vehicle crossed them.

I am certainly at a loss to understand this insistance of some surveyors for elasticity in a paved road, unless it be for the preservation of the horses' feet, which do not last so long on the "stones" as on a softer road. As for the mechanical effect of traction, it is totally opposed to all laws of mechanics for easy traction; and McAdam's theory, of the top stones rubbing against a concrete bottom, and thus wearing round, and being displaced, and from whence I imagine the present desire for elasticity comes—as the top pavement is a fixture—is untenable. I think it might be laid down as a rule that the harder the bottom of a road is the better, whether for wood, asphalte, granite, or broken stone, and if you do not start with this initial you will never have a sound roadway. The difficulty to be overcome appears to be in keeping the wet from percolating through the joints, which are made wide so as to give a better foothold for horses. I think it is a questionable mode of laying pitchers, whether of wood or stone. I prefer having the joints closer than I have hitherto seen them for wood; first, because there is less chance of the water finding its way to the foundation; secondly, these joints always wear away quicker than the blocks, leaving innumerable places for the lodgment of horse dung and filth; thirdly, the traffic wearing the pitchers round (a demonstration of this can be found in Derwent Street); and a small joint, so long as it is a perceptible joint, is a preventative to slipping, and enables a horse to rise if it falls.

There now remains an examination of asphalte as a material for paved roads.

The most noted of these is that of the Val de Travers Company, which is described as limestone, containing about 12½ per cent. of

bitumen, obtained exclusively from Neuchatel, Switzerland. It is claimed for it that neither "atmospheric heat nor frost affects it." In laying it for roads it rests on a bed of concrete sufficiently thick to stand the traffic. The asphalte in its natural state, reduced to powder, is brought to the works hot, and compressed with heated irons and rollers uniformly over the entire area to be covered, leaving no surface seams or joints. It is laid about 2 inches to 2½ inches in thickness.

The next asphalte that has attracted attention is that termed Limmer. This, like the previous material, is laid on concrete. It is brought from Hanover, mixed with a certain proportion of sand and bitumen (the Company say that the asphalte contains from 17 to 20 per cent of bitumen), heated in caldrons, and laid on to the concrete about 2 inches in thickness, and then is smoothed with irons to the requisite surface.

There are several other asphaltes that have been tried, but only to a limited extent, except perhaps Barnett's, which appears to be a mixture of pulverized iron ore and mineral tar made liquid by heat, and spread, as the other asphaltes, about 2 inches thick.

The battle of the materials is almost as fierce as the "battle of gauges." The promoters of asphalte and wood pavements both claim the same merits, and there appears to be a diversity of opinion amongst those competent to judge as to which is the better material of the two. The Engineer of Bristol says: "My experience of asphalte is not large or favourable; the first cost of Val de Travers was 16*s.* 6*d.* per yard, but it has not lasted here more than 6 years, and is now in a very bad condition; the wood will require repair in four or five years."

No asphalte is to be laid in the Birmingham roadways, as the gradients are so unsuitable.

As a material for footpaths, Mr. Till, C.E., the Borough Engineer, says, "I cannot speak favourably of its durability."

The City of London Engineer, Mr. W. Haywood, C.E., has prepared an elaborate report on the subject, setting forth in detail the result of his experience of both wood and asphalte; and as no one has either had such opportunities or facilities to come to fair conclusions in the matter, I extract those conclusions verbatim from his report. They are:

"*Firstly.*—As regards convenience.—That asphalte is the smoothest, driest, cleanest, most pleasing to the eye, and most agreeable pavement for general purposes, but wood the most quiet.

Secondly.—As regards cleansing.—That wood may be kept cleaner than it hitherto has been, but will be more difficult and expensive to cleanse effectually than asphalte. That as both pavements require occasionally strewing with either sand or gravel, there is not much difference between them in that respect.

Thirdly.—As regards construction and repair.—That asphalte and wood, taking all seasons and all weathers into account, can be laid and repaired with about equal facility, but that the smallest, neatest, cleanest, and most durable repairs can be made in asphalte.

Fourthly.—As regards safety.—That whether considered in reference to the distance which a horse may travel before it meets with an accident, or the nature of the accident, or the facility with which a horse can recover its footing, or the speed at which it is safe to travel, or the gradient at which the material can be laid, wood is superior to asphalte.

Fifthly.—As regards durability and cost.—That wood pavements with repairs have in this City had a life varying from six to nineteen years, and that with repairs an average life of about ten years may be obtained; that the durability of the asphaltes is not known, but that under the system of maintenance adopted, they may last as long as wood; that contrasting the tenders for laying and maintaining for a term of years the two best pavements of their kinds, wood will be the dearest."

We must remember that Mr. Haywood is speaking of ordinary fir timber, unpreserved in any way. Probably his opinion would be materially altered if he was aware of the durability of the creosoted timber in Sunderland.

Mr. Haywood, in reporting on the comparative safety of these materials, says that a horse would travel 132 miles before a fall took place on granite; 191 miles on asphalte; and 446 on wood. This is the experience of London streets; but we cannot be guided by that in Derby. It is the practice in London to move all railway vans and a large proportion of heavily weighted vehicles at a trot. With us such vehicles are transported at a walking pace, and as accidents increase *pro rata* with the speed and load, we should not be liable to anything like so many.

My own comparisons of these materials are that for a very large number of streets where the roadway is fairly wide, where there are few shops, and where the occupation of the inhabitants is such as noise would not be a great objection, granite is the cheapest and best material that can be used. That in streets of business, where

absence of noise is a desideratum, preserved wood paving is the best, though it is expensive. That asphalte is an impracticable material to use in our town, where it would frequently have a greasy surface, unless there is some means of making it less slippery in damp weather. I have had submitted to me a model by the Val de Travers Company, which shows an introduction of small iron studs on the surface, with asphalte between; but my experience goes to prove that the mixing of two materials differing so essentially in their toughness and hardness is quite wrong; that the studs would in a few years be left so high by the wear of the asphalte as to be dangerous.

Before closing this paper, I should like to call your attention to the existing mode of cleansing streets, and recommend the use of horse brushes and scrapers, and the doing away as much as possible with hand sweeping (it cannot be avoided in some conditions of the weather), for I find that while a man can sweep about 2500 square yards per day or a little more than half an acre, a sweeping machine will sweep something like 45,000 square yards, or about 9½ acres, and the same can be scraped by a scraping machine, probably a little more. They thus effect a large saving, and I am of opinion that Fairbairn's machine, which swept the slop into the cart, is a still more economical way of cleaning streets, and I shall endeavour to obtain some facts with reference to it to lay before you at a future time.

It would take seven machines or rotary brushes to sweep the streets of Derby once a day. At this rate, looking at the narrowness of some of the streets, in times of continuous rainfall, we should require ten of these machines to sweep the streets once a day; and, taking two loads of mud for each thousand yards of roadway, each cart drawing ten loads of mud in ten hours, we should require 63 horses and carts to cleanse the town; and with the rainfall such as we have had this spring, to have kept the streets quite clean, looking at the state of repair they were in, this is under-estimating the staff required. Of course there is a long mileage of streets that would not require to be swept each day, but in those streets requiring cleansing in the centre of the town, upwards of three loads of mud would be taken from an average of 1000 yards of roadway, and, as a matter of fact, only five loads of slop or mud can be taken away by a horse to the existing shoots. These main thoroughfares, comprising 100,000 yards of roadway, would have required 60 horses to remove the slop during last winter, so as to

keep the streets clean. I find that during the 24 weeks ending March this year, there was an average of 344 loads of mud removed per week. During the greater part of that time, the roads were either in so bad a state of repair, as to be swept only once or twice a week; or during the remainder a large area had been recently repaired with granite, and consequently was not swept, so that this affords us no sort of criterion as to the quantity that would come off our roads under ordinary circumstances, but it is an indication of the cost. I find that this cost us 816*l.* 12*s.*, or within a fraction of 2*s.* per load; this would give us a cost of 30*l.* a day for the throwing of the slop into the cart, and removal of same to a shoot; add to this the cost of the sweeping up of this mud—say three machines in a bad weather—this adds 36*s.*, and we have 31*l.* 16*s.* as the cost of thoroughly cleansing the thoroughfares in the centre of the town.

I have also turned my attention to the watering of the streets. The cumbersome old-fashioned tub water-cart still drags its weary length along, at a large cost and with unsatisfactory results. Bayley's hydrostatic van, is a step in the right direction, and would save a considerable sum if adopted; for it is found that in the City of London, where fourteen vans are used, formerly twenty-one carts were required, and a saving of 420*l.* per annum has been effected by their use, or 33 per cent. Horse hire for watering cost the Authorities at Derby 426*l.* for the year 1874–75—had Bayley's vans been in use it would have cost 284*l.*, at the same rate of saving as in London, and I see no reason why the adoption of these vans should not result in as great a saving elsewhere, but the principle of carrying about on wheels, by horse hire, a fluid which can be got on to the roads, by gravitation, in a town with a constant supply of water is an anomaly! "They manage these things better in France," is an adage we have to learn the truth of in this matter; for in Paris the streets are watered by hose from the street hydrants, and this system has been adopted in Reading, and there are no insuperable difficulties of its adoption here if you will try it.

The necessity of well watering the carriage-ways of streets during the dry season of the year must be recognized by every one. The question is how to carry out this work regarding the cleanliness and health of a town in the most efficient and least costly manner. In Reading,* which has about 23 miles lineal of public

* See vol. ii., p. 176.

roads, all unpaved, 17 miles are usually watered twice a day; and for this purpose eleven watering-carts and barrels and four hand-watering machines have recently been introduced on trial by the Board. The following particulars will give a comparative view of the cost and efficiency of the two modes:

A superficial area of 23,849 yards can be watered by a watering-cart twice a day, for one width or 5962 yards lineal; or for a double width, 2981 yards lineal; the cost will be—for horse, cart, and man, 8/-; maintenance of carts, harness, shoeing, &c., 1/5, or a total of 9/5 per diem.

The hand machines used in Reading are four in number, three of special make somewhat resembling those used in Paris, and one of Headly's drum machines. There is no difference as regards the efficiency of the two descriptions of machines, as either performs the same amount of work, the space watered by one of either pattern being an area of 23,740 square yards twice daily. Headly's machine was purchased new five years ago, at a cost of 31*l.* 7*s.* 3*d.*, and the annual amount expended on repairs and maintenance since that date has been 4*l.* 8*s.*, making a total cost of 22*l.*

The price of the other description of machine, when new, was about 20*l.*, and the average yearly expenditure on its maintenance has been about 3*l.* 18*s.* These are not likely to supersede Headly's machine for a considerable period.

To work the hand machines, two men are employed daily at 2/10 each, as it requires one man to attend to the attaching and detaching of the apparatus to the hydrants. The cost of maintenance and repairs is also 7*d.* per diem; so that the total daily cost averages 6/3 as against 9/5 by carts. By this mode we should have saved 142*l.*, or 33 per cent.

These hand machines deliver 1·30 gallon of water to the square yard, while the water-carts deliver only 0·51 gallon to the same area; so that, as regards the quantity of water laid on, it will be seen that the advantage is all on the side of the former.

The main conclusions come to in this paper are—

I. That the direction of roads requires to be controlled by the Authorities.

II. That in constructing Macadam roads, there should be a "rough-paved" foundation.

III. That in wide roads the channel should be in the centre, and not at the sides.

IV. That granite, wood, and asphalte may all be used in different localities with advantage as a road-making material; (*a*) granite in streets of heavy traffic, where noise is not a matter of much consideration; (*b*) wood in streets where absence of noise is a matter of importance; (*c*) asphalte in dry districts with flat gradients, where the Authorities will keep it well cleansed.

V. That machine sweeping by horse-power is much cheaper and more effectual than hand sweeping.

VI. That the existing mode of watering streets by a cart is costly and ineffectual, and that it can be accomplished cheaper and better by hand machines.

[APPENDIX

APPENDIX, showing Examples of Paving, &c., in the Borough of Derby, 1876.

TABLE I.—Streets proposed to be Paved, now Macadamized.

Name of Street.	Area in Yards.	Present Mode of Repair.	Maintenance, Cost per Yard per Annum.	Cost of Cleansing, per Yard per Annum.	No. of Vehicles in 12 Hours.	Remarks.
			s. d.	d.		
Bridge Gate	2931	Broken boulders	1 6	6½	1268	
St. Helen's Street ..	1203	" granite	1 2½	5¼	585	
Wardwick	984	" "	1 2½	8½	1258	Cleansed every day.
Iron Gate	1562	" "	0 7¼	4	1506	
Corn Market	1695	" "	0 7¼	3½	2031	
St. Peter's Street ..	3230	" "	1 2½	3	2762	
London Road ..	4859	" boulders and granite	0 7¼	2	1272	Area given for Borough only.
London Street ..	2847	" "	0 10¾	3	1200	
Tenant Street ..	1245	" "	1 2½	3¾	1250	
St. James's Street ..	995	" "	0 5½	4½	711	
Siddals Road	4728	" "	0 7¼	3	1931	
Derwent Street ..	3483	Paved, 5″ × 3″ pitchers.	*nil*	2¼	1658	This street has cost nothing for repairs in seven years.

Note.—A Macadamized street in Bristol, 718 yards long, 13 yards wide, cost per annum nearly 1000*l.* to repair and maintain, or 2*s.* 1½*d.* per square yard = 2425*l.* per mile. Regent Street, London, costs 3*s.* 7*d.* per square yard per annum to maintain Macadamized.

TABLE II.—Granite (Construction and Maintenance).

Name of Street.	Area in Yards.	Proposed Mode of Paving.	First Cost per Yard.	Total Cost per Yard, including Maintenance.	Average Annual Cost per Yard.	Estimated Duration of Pavements in Years.	Remarks.
			s. d.	£ s. d.	d.		
Bridge Gate	2931	Granite, 5″ × 3″ pitchers	13 0	1 0 6	10¼	24	This would include taking up, re-dressing, and relaying once in this period, for all the following streets.
St. Helen's Street ..	1203	"	13 0	1 0 6	8½	29	
London Road	4859	"	12 6	0 19 0	7⅛	32	Probably this pavement would last longer than thirty-two years.
Tenant Street ..	1245	"	13 0	1 0 2	8½	28	
Siddals Road	4728	"	12 6	0 19 0	7⅛	32	

Note.—The value of the old materials at the expiration of the foregoing terms would be equivalent to the cost of removing the existing Macadam.

TABLE III.—RELATIVE COST OF DIFFERENT KINDS OF ASPHALTES AND WOOD.

Name of Material.	First Cost per Square Yard.	Period over which Company will maintain it at fixed sum.	Average Annual Cost, including Maintenance, per Yard per Annum.	Terms of Payment.	REMARKS.
	s. *d.*	yrs.	*s,* *d.*		
Limmer asphalte	16 0	13	1 9¾	Not stated	This does not include the cost of removing existing Macadam, which would be at the rate of 4*s.* 6*d.* per yard cube "as it lies." This includes concrete.
Val de Travers asphalte and iron studs.	17 6	Not stated	..	Nett cash in 6 months	Owing to the patent having only been just completed, the Company are at present unable to give particulars in full.
Creosoted wood (Armstrong and Addison).	11 7	16	1 1$\frac{3}{16}$	Not stated	This does not include cost of removing existing Macadam. This includes concrete.
Carey's wood	14 9	10	2 10½	80 per cent. monthly, 10 per cent. in 3 months, balance in 2 years.	This does not include concrete foundation, which would cost 2*s.* per yard additional if required (Mr. Carey usually dispenses with concrete), nor cost of removal of Macadam.
Asphaltic wood pavement	14 3	13	1 8¼	70 per cent. on completion, balance in 12 months.	The price given includes concrete. Excavation and removal of existing Macadam 1*s.* 3*d.* per yard super. extra.
Ligno mineral paving:					
Yellow deal	11 6	17	1 9¾ }	On completion of works.	This includes concrete, but not removal of Macadam.
Hard wood	14 6	17	1 3½ }		
Improved wood pavement	15 0	16	1 8½	90 per cent. on completion, 10 per cent. in 12 months.	Cost of removing Macadam, 1*s.* per square yard of pavement.
Granite	13 0	..	0 8¾	.. ..	It is estimated that granite would last 28 years in this calculation.

TABLE IV.—COMPARATIVE COST OF GRANITE PAVING AND MACADAM.

Street.	Granite Paving, 5 in. × 3 in. Pitchers.												Macadam.		
	Total Cost of Paving and Maintenance, per Yard.			Estimated Cost per Yard for Cleansing, per Annum	Total Estimated Cost, including Construction, Maintenance, and Cleansing, per Yard.			Total Cost of Street Paved over entire Area, in 25 Years.			Life of Street in Years, Paved.		Total Cost of Street Macadamised over entire Area, in 25 Years.		
	£	s.	d.	d.	£	s.	d.	£	s.	d.			£	s.	d.
Bridge Gate ..	1	0	6	2¼	1	5	0	3663	15	6	24		6980	18	0
St. Helen's Street	1	0	6	2	1	5	4	1523	16	0	29		2870	17	4
London Road ..	0	19	0	1	1	1	1	5264	0	11	32		5992	18	0
Tenant Street ..	1	0	2	1¼	1	3	8	1473	3	10	28		2650	15	8
Siddals Road ..	0	19	0	1¼	1	2	4	5279	12	0	32		6408	18	8

TABLE V.—PLACES WHERE WOOD AND ASPHALTES HAVE BEEN LAID.

Name of Material.	Date of Laying.	Locality.	Remarks.
Asphaltic wood ..	1874	Cannon Street, London	There is a very trying omnibus traffic here.
„ „ ..	1875	Hart Street, London.	
„ „ ..	1875	Barbican, London ..	Large traffic here, in a narrow street.
Creosoted blocks (Armstrong & Addison).	1867	Wearmouth Bridge ..	40,000 vehicles a month pass over this street.
Improved wood ..	1871 1872	Bartholomew Lane. Gracechurch Street. King William Street.	All these streets are in London, and have a very heavy traffic. That of Gracechurch Street and King William Street is enormous.
Carey's wood	1872	Cannon Street, London	There is a very trying omnibus traffic here.
Ligno mineral wood	1868	Rue de Dragon, Paris	Also in several other streets in Paris.
„ „ ..	1868	Gracechurch Street. Fore Street	An enormous traffic here.
Limmer asphalte ..	1871	Lombard St., London.	
„ „ ..	1871	High Street, Southwark.	There is a very trying traffic here.
„ „ ..	1871	Moorgate St., London	Heavy traffic here.
Val de Travers asphalte.	1871	Cheapside, and many other streets.	There is an enormous traffic here.

NOTE.—Samples only are given. All the above (except Armstrong and Addison) have laid streets in various other towns all over the kingdom.

DISCUSSION.

Mr. Lynde said the paper on roads was full and explicit. There was very little to say upon it. When at Liverpool he was asked why they did not concrete their roads in Manchester; when he saw a town by means of concrete better paved than Manchester he would use it. Everybody was pleased with the pavement of Manchester, and they had no concrete. He did not think he should gain anything by it.

Mr. Purnell said one objection to Mr. Clark's paper was this: he had gone into the mathematical too much, and had not dealt with the practical sufficiently.

Mr. Deacon said that five years ago, when considering the future pavements of Liverpool, he visited Manchester, and upon examination came to the conclusion that it was the best paved town in the kingdom; and all things considered, he was still of that opinion. He could not, however, agree with Mr. Lynde as to the uselessness of concrete, although at first he (Mr. Deacon) adopted Mr. Lynde's system in the exact form in which he found it, and those streets in Liverpool which had been paved in the manner described in the paper just read were far more satisfactory than any of earlier date. When the surface of a street was rendered impervious by using asphalte for the joints, one of the chief causes of unevenness was obviated. But in streets of heavy traffic, however well the foundation was rolled, and even where that foundation was formed of thoroughly consolidated hand pitching, he found notwithstanding the impervious surface that the carriage-way did sink in places, and that the deterioration was not simply due to the wear of the stone surface. He had therefore used Portland cement concrete foundations to a very large extent, and the difference between otherwise similar carriage-ways with and without the concrete foundation was most palpable, while there could be no doubt that it would become more so by lapse of time. The concrete was everlasting, and actually increased in strength as it grew in age, so that the question of maintenance need only be considered in relation to the surface. The chief objections taken to the use of concrete were the difficulty and cost of obtaining access to the water and gas mains, and the inconvenience involved in the preparation and laying of concrete in crowded thoroughfares and the time

occupied in setting. As regarded the first point, experience had shown that the gas and water mains could be reached and covered at no greater expense than in ordinary cases. The sets could be taken up and relaid as easily with as without concrete, and the concrete, if properly made, could be sawn out with saw picks in blocks 3 or 4 feet square, after the manner in which a quarryman proceeded to cut a slab of rock. These blocks were lifted and laid on one side. When the trench had been filled up with the excavated material, well watered and rammed, they were relaid, the joints being made with strong Portland cement mortar; the sets were at once replaced, and the traffic passed over the trench on the following morning. In no instance had the site of the trench become visible, though this mode had been adopted in streets of the heaviest traffic. Compare with this the well-known and ever-sinking trench, which after being repaved twice, thrice, or even four times, rarely failed to leave its mark. Now, as to the inconvenience of laying concrete in crowded thoroughfares, he would admit at once that some inconvenience was inevitable. In Liverpool that inconvenience was made as short as possible by boldly closing the carriageway and relaying the whole width at once. But even then, when employing the ordinary system of mixing concrete, he had found a difficulty owing to the small space available in working a proper number of mixers and leaving room for carts with materials to pass. This difficulty had, however, been successfully met in a manner which he must crave some little time longer to explain, as it was a dangerous experiment to try unless the limits of its success were thoroughly understood. It had hitherto very properly been made by all engineers a *sine qua non* that mortar or cement should be mixed and gauged with water once, and only once. If after being allowed partially to set it was disturbed, many of the crystals already beginning to form in the process of setting were separated and did not again join, so that although the setting would continue after the second mixing, the mass never recovered entirely from its disintegrated condition. Some cements, such as Roman, plaster of Paris, or imperfectly burnt Portland cement, began, as was well known, to set almost immediately water was applied to them, and a very general belief prevailed that although certain other cements or limes were much slower in attaining a condition of hardness, the process of crystallization, though it progresses much more slowly, commenced almost immediately after the application of water, so that any further dis-

turbance was detrimental. He (Mr. Deacon) had long believed that this was not necessarily the case, and in order to put it to the test blocks of slow-setting Portland cement concrete, each measuring 1 cubic foot, were prepared under precisely similar conditions, with the single exception that some were moulded immediately after mixing, and others after various periods of time had elapsed. They were all ultimately tested by compression in a very delicate machine constructed by Sir William Armstrong and Co., in which the pressure was applied by hydraulic power, but measured on the opposite side of the blocks by a system of levers and graduated scales, thus eliminating all error due to the friction of the hydraulic press. Unfortunately some of the blocks failed to break under 50 tons, the maximum load of the machine; but the following table shows the general results which were sought for.

Experiments to ascertain the difference in strength of concrete mixed uniformly and placed in boxes 12 in. × 12 in. × 12 in. at different intervals of time.

The cement used was Portland (tested tensile strength 800 lbs.), the gravel from the Isle of Man screened through a ¼-inch sieve.

Proportion of mixture of Portland cement = 1 part gravel = 5 parts in bulk.

	Intervals between the Completion of Mixture and Filling of Boxes.								
	90 Minutes.	75 Minutes.	60 Minutes.	50 Minutes.	45 Minutes.	40 Minutes.	30 Minutes.	20 Minutes.	No Interval.
	tons.	tons.	tons.	tons.	tons.	tons.	tons.	tons.	tons.
Crushing strains applied twenty-eight days after moulding	..	..	49·6	..	..	..	50*	50*	43
	37·5	43·5	42·75	47·75	50*	50*	50*	48	49·75
	50*	50*	48·75	47	50*	47·85	50*	..	50*
	..	..	46	..	..	..	50*	..	..
Average strain in tons	43·75	46·75	46·77	47·37	50*	48·92	50	49	47·58

The blocks marked 50* stood the full strain of the machine without being crushed.

This table would be imperfect if the specification of the cement made use of in the blocks and generally in the streets were not added.

The cement made use of for this purpose is distinguished as *slow setting* in the following specification.

Specification of Portland Cement.

The cement must be of uniform quality and capable of bearing the following tests to the satisfaction of the engineer:—

1st. Samples of the cement being sifted through a number 50 gauge wire sieve, must not leave a residue of more than 10 per cent.

2nd. Samples of pure cement will be gauged with water and placed in the brass moulds B used by the Corporation. Within twenty-four hours the casts thus made will be immersed in still water, in which they will remain until the expiration of seven days from the date of moulding; when they will be taken out of water and tested to ascertain their tensile strength, which must not be less than 800 lbs. on the sectional area of 2¼ square inches.

3rd. In ordering the cement it will be distinguished as quick setting or slow setting. The slow setting cement when gauged neat in the B moulds, must not become firm in less than three hours. The quick setting cement must assume a firm condition within half an hour. The test for firmness will be that of resistance to the finger nail, the test at present adopted in the department.

The above tests will be applied after each delivery, and should the result be unsatisfactory to the engineer, he may—having given notice to that effect to the contractor within eleven days of delivery—require the whole of such cement to be removed at the contractor's expense.

With each delivery the contractor shall send a memorandum of the quantity delivered and the name of the manufacturer.

With the knowledge which those experiments gave, he (Mr. Deacon) felt justified in allowing the concrete to remain after being mixed for twenty or twenty-five minutes before being laid, and this gave abundance of time for cartage from the nearest yard or vacant space, where in a horse-shoe form the mixers worked to advantage around the carts. The gravel and cement mortar having been carted to the work, was spread over the hard bottom in a layer about 2 inches thick, and upon it was scattered hard stone, broken to the size of macadam. This having been beaten well in, another layer of mortar and another of stones were thrown on, and the beating process resumed. When finished to 6 or 8 inches thick no trace of lamination appeared, for the angles of each layer

of stones had been beaten thoroughly into the interstices of the layer below, while each stone was separated from, but joined to, its neighbour by a layer of cement mortar. The samples of concrete formed in this manner, which lay upon the table, were evidence of the satisfactory results obtained. The cost of the work, not including credit for the old sets or other materials removed, was as follows:—

MEMORANDA AS TO IMPERVIOUS PAVEMENTS WITH FOUNDATIONS OF PORTLAND CEMENT OR BITUMINOUS CONCRETE.

	s.	d.
Portland cement concrete, 5 inches thick, per superficial yard; Dee gravel, 6s. 6d. per ton; broken stones, average 5s. 3d. per ton; Portland cement delivered, 54s. per ton.	2	9

	d.
Stones	6
Cartage	1·1
Gravel	7·9
Cartage	1·4
Cement	12·7
Labour	4·2
	2s. 9·3

	s.	d.
Paving with sets, 5 inches to 8 inches long, 3½ inches thick, 6 inches to 6½ inches deep, at 26s. 6d. per ton; jointed with pitch, at 32s. 6d. per ton; and creosote oil, at 2½d. per gallon; shingle, at 7s. per ton.	9	9

	s.	d.
Sets and cartage	7	6
Gravel	0	5.1
Cartage	0	2·8
Labour	0	5·7
Pitching joints	1	1
	9	8·6

3¾ yards of paving take 1 ton of sets.

Cost of pavement and foundation exclusive of excavating or credit, 12s. 6d. per yard superficial	12	6

Similar pavement to the above, on bituminous concrete foundation, 8 inches thick = 4s.; would cost 13s. 9d. per yard.

Material used in concrete 5 inches thick:

Broken stones = 2 cwt. per yard superficial.
Gravel .. = 2¼ „ „
Cement .. = 0·30 „

In reply to questions, Mr. Lynde said that in Manchester the asphalte had been done in the joints thirty-two or thirty-three years.

Mr. DEACON said his sets at Liverpool varied from 6 to 7 inches deep.

Mr. LYNDE considered 6-inch sets stood remarkably well.

The discussion was then adjourned.

SECOND DAY.—Friday, July 7.

The President announced that the discussion on street pavements, and the construction and maintenance of roads—two very important subjects—would be resumed.

Mr. Buckham said Mr. Ellice-Clark's paper, which he thought an extremely valuable one, contained some statistics as to the difference of paved and macadamized roads, and he stated that when the traffic arrived at a certain pitch the road should be paved. He never arrived at these figures himself, but he was very glad to hear them, because he was favourable to macadamized roads, and in his opinion there were no roads to be compared with them for comfort and other advantages, both in respect to vehicular and foot traffic. Of course there were counter-objections that macadamized roads, according to the material used, produced a large amount of mud in winter, and dust in summer, and also that the expense for scavenging was considerable. Mr. Ellice-Clark had not given any figures as to the cost of scavenging, perhaps his memory did not serve him, but he should like to know the difference of scavenging macadamized roads with certain traffic per mile, and the cost of scavenging the same area of paved roads. Moreover, the noise created by the traffic over paved roads was something intolerable; indeed, in consequence of this he had not been able to get hardly any sleep at his hotel during the previous night. Perhaps Mr. Ellice-Clark would be kind enough, if he did give any figures in his paper as to scavenging, to repeat them. He did not quite agree with his paper as to the making of a channel in the centre of the road, and of putting lamps in the middle of the road. A great deal of attention had been paid to the making of roads ever since McAdam's time, and he was not prepared to disprove Mr. Clark's argument, but he was doubtful whether a road with a channel in the centre would be advisable, as there must be a slight incline towards the channel. The gradient of 1 in 30 was suggested, but the tendency of such a construction would, he thought, be that the mud in winter and the dust in summer would collect in the channel, which, of course, would be very detrimental. He must thank Mr. Clark for his paper, because he thought it was an admirable one, although he did not altogether agree with its contents.

Mr. Ashmead (Bristol) said, with regard to the comparison between the two kinds of roads, he thought the cost of one was about three times that of the other. Some twenty years ago he went to Manchester, and was so pleased with the way in which the streets were constructed there, that he adopted the principle, he believed in its entirety, in Bristol, and he might say that he thought that principle obviated the necessity for concrete foundations, because it was impervious to water, and if the water were kept out a very important point had been achieved. With regard to stones, he gave preference to the North Wales, and their durability was such that he had some streets which had been paved for twenty years with them, and they would never have required any alteration if the gas and water people had left them alone; in fact, he believed they would last for ever, so to speak. He had also tried the Val de Travers stone. He had constructed a bridge over one of their streets with iron top, and he wanted to preserve it from leakage, and he used Val de Travers on the top, but from some cause or other it had completely perished; whether vibration or want of thickness was the cause he could not say, but it completely perished after about four years' wear. He had used wood in two of the principal streets, improved wood in one and asphaltic wood in the other; the improved wood had to be improved once in two years, partly in consequence of the water having got into the foundation, which must, in the course of time, rot the boards forming the foundation. The joints were made with the usual asphalte. The asphaltic wood, as they knew, prevented the water from getting to the foundation; but the question was, whether the dry rot would ensue, but time alone would prove that. With the little experience he had had he estimated that the duration of wood extended over about four or five years, according to the traffic. The cleanliness and noiselessness of the wood was so preferable that the Bristol people would not return to the use of granite, although now it only cost one-third of what it did. With regard to the centre channel, that seemed to him like going back to the old style.

The President considered the question as to granite paving and macadamized roads was a very important one; he thought it must depend entirely upon the amount of traffic. The way he should arrive at it would be this—he should calculate the original cost of paved roads, and the cost of cleansing and maintaining them per annum, and compare the figures with those arrived at in respect to macadamized roads. He had just roughly made a few figures as

to the cost of a paved road. Taking a street 10 yards wide, and working it out at 10*s*. per yard—that was rather a low price—it would come to near 8000*l*. per mile; the interest alone on that amount would be 400*l*. a year. There were not many macadamized roads, unless there was a very great amount of traffic, cost 400*l*. a year per mile; the maintenance of the roads in his district did not cost above half that sum.

Mr. Ashmead: I have one that costs 1000*l*. a year.

The President said that showed that when they got the amount of traffic they must draw the line at something like 400*l*. In reference to asphalte, he had laid a portion of a road in Southampton with Val de Travers, and he might say that it was one of the best pieces of road in England, and it wore exceedingly well; there certainly was not a large amount of traffic upon it, but it was not slippery, and that was because he spent a little money in keeping it clean. A good many people entertained the idea—in fact that was one of the advantages of asphalte—that the cost of cleansing was saved by means of asphalte, and they consequently left it to look after itself; at first he ran away with that idea, but his experience had taught him that an asphalte road required more attention than an ordinary road, or else it became very slippery. As regarded wood paving, he was instructed to report on the subject to his Board, and very curious to say, he arrived at the same result as Mr. Ashmead at one and the same time—that was, that wood paving was constructed on a wrong principle, the foundation being rotten by the permeation of water through the joints. He once took particular notice of a wood road on London Bridge, and when vehicles passed over it the water actually oozed through the joints. The Improved Wood Paving Company had taken a great deal of trouble, but they had not solved the difficulty; the fact was, that the wood shrunk, and the water found its way through the foundation. He then advised his Board, if they thought of introducing wood paving, to adopt granite blocks on concrete foundations in asphalte, and he mentioned this to a gentleman in London, who thought it worth his while to take a patent out for it; he did not think so himself. The asphalte wood pavement was the best system they could adopt if they used wood. The first thing in constructing a road was to have a good foundation; the second and third things the same; in fact, the foundation was everything. As regarded concrete he was in favour of it, and in his opinion

the secret of the success in Manchester was that by means of ashes, &c., they made a foundation like concrete (Mr. Lynde, "Better"). He walked upon this preparation before the stones were laid, and poked it about with his stick, but it was so hard that he could not move it. In Manchester there were opportunities of getting ashes, but in those places where ashes could not be obtained concrete was the next best thing. With regard to their friend's notion about lamps in the middle of the road, perhaps in respect to the lighting it would be a good principle, as both sides of the road would be lighted by that means. But he should be sorry to go back to that idea; they knew their friend to be a thorough radical Member, and he brought forward some excellent views, but he could not see how on a dark night, when the lamps were not lighted, he was going to prevent a cart from running up against the posts. If he purposed to erect lamps in the centre of a road, he should put a kerb round the posts; nevertheless, the principle was deserving of very careful consideration, and Mr. Ellice-Clark must be accredited with the originality of the design.

Mr. Monson said, on a visit to Blackburn he was struck with the remarkably nice corners they get to the pavements, and he had adopted them at Acton. He had put down a corner, and then came the question of measuring. The rule was to measure what is laid and allow nothing for waste, whereas with these corners they must allow for waste in measuring. A surveyor in London had told him that he should take the two greatest lengths, whereas a gentleman who lived in the district advised him to take the square out and double it. He should be glad to know what was the practice of measuring pavement.

Mr. Ashmead said, whatever the contract said must be abided by.

Mr. Lobley said the practice was to square out to radii and add one-quarter, making it considerably more than the actual area, and allow for waste in turning the corner.

The President thought the fairest way was to take the greatest length of the stones.

The Hon. Secretary said, when speaking of the original cost, it should be understood whether the roads were constructed of broken granite or any material that might come to hand; that distinction should be made, because the material used made an enormous difference in the cost. He could understand if a road, spoken of as a macadamized road, was formed of shingle merely, would cost only 20*l.* a year in maintaining it. One of the

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high roads in his district about two miles in length cost about 1200*l.* a year, and he should like to be able to do it at one half that amount if it were possible.

Mr. Angell said he had a road which cost 800*l.* per mile per annum; it was formed of broken granite. He did not think a flint road would be called a macadamized road in the ordinary acceptation of the term.

Mr. Lynde said a macadam road was a road made of broken stones.

The Hon. Secretary said there was one point he should like to hear a remark upon, that was as to the advantage of small size or irregular cubes over the larger size.

Mr. Lobley said the cast of maintaining the macadamized roads in his borough did not exceed 50*l.* a mile a year, he was referring to the maintenance and not the first cost. Of course the country was very hilly, and he thought the weather wore away the roads almost more than the traffic; in case of a severe storm the top of the street was nearly brought to the bottom. He thought macadam was not necessarily granite, but any broken stones; broken as nearly cubical as possible. He used the basalt, and also the Leicestershire, which he found much cheaper than anything else for his district. There was a great difference in the wear of the streets, but there were very few indeed in his neighbourhood that cost anything like 400*l.* a year. With regard to the size of the sets, he had introduced two-and-a-half, and he found they were very much liked, and they wore very well.

Mr. G. Cole (Hereford) said he had adopted the smaller size, which made a very good surface; he used the Cleeall sets, and they answered the purpose remarkably well.

Mr. Monson thought the cost of maintaining the macadamized roads in the neighbourhood of London was about 800*l.* a mile; the cost in his parish was 500*l.*

The President said he had reduced the size of macadam in his place to one-and-a-half inch, and it made a much better road, and a more even surface than the larger size. He used Guernsey granite, because it was close at hand, and the cost was 11*s.* 9*d.* per cube yard delivered alongside already broken.

Mr. Angell: Do you pay more for having it broken smaller?

The President: About 1*s.* per yard more.

Mr. Ashmead had tried nothing less than two-and-a-half inches.

Mr. Lynde said the old size was always two inches.

Mr. Ellice-Clark then replied. As most of the Members took

exception to the centre channel principle he would beg of them to think carefully over his idea; for himself he was fully convinced that was the best way of making the roads. He must admit that the idea of lighting a road in the centre was untenable, but as to the channelling in London he found many cab stands, and safety crossings in the streets, and these did not prove any inconvenience. The section of the road he proposed having a gradient from the sides to the centre of one in forty would not present that singular appearance that some thought it would do. Mr. Buckham wanted to know whether he drew a line showing where pitching should be used, and where macadam should be used; he had presented to them a tabulated statement, from which it would appear that only one or two streets in Derby were pitched, all the other streets being macadamized. In Bridge Gate, for instance, there was a very heavy traffic, the cost of paving and maintaining it in twenty-five years would be 3660*l.*, while the cost of keeping it macadamized would be 6900*l.* To show where to draw the line, he might say that London road the cost of paving would be 5200*l.*, and that of the macadamizing 5900*l.* With regard to the cost of maintaining roads it was an error to calculate the area by the mile, the proper way was to take a superficial yard, as streets varied very much in their width. As to cleansing, the cost for this in the case of macadamized roads averaged 6½*d.* per square yard, and 2¼*d.* for paved roads; the maintenance per superficial yard came to about 1*s.* 6*d.* for macadam, and 3*d.* for pitching. He was glad to have heard the President put in a strong protest against improved wood paving; it appeared to him that it was thrust into the market by speculators without possessing the merits which it was said to have done. He expressed his surprise that preserved wood was not more used in the roads, and mentioned that at Sunderland some of this wood had been down since 1867 without being worn to any appreciable extent, notwithstanding that over 40,000 vehicles were monthly passing over it. Mr. Johnson, Engineer to the Great Northern Railway Company, had told him that the reason they did not use creosoted wood was not because they did not believe in it, but because they could not get it as they wished. Having referred to the objections of asphaltic wood paving, he concluded by stating with regard to measuring pavement that the best method was to take the greatest lengths. (Applause.)

On the motion of the Hon. Secretary and Mr. Ashmead, Mr. Royle and Mr. Ellice-Clark were thanked for their able papers.

H 2

THE LEEDS SEWAGE WORKS.

By Mr. A. W. MORANT.

The borough of Leeds contains, within an area of 21,572 acres, a population estimated in June, 1876, at 291,580. The district is very hilly, and varies in level from 70 feet above Ordnance datum at the river near the outfall, to 500 feet above. It is traversed from N.W. to S.E. by the river Aire, and the natural drainage is also carried off by the Addle or Sheepscar Beck and by Gipton Beck, on the north side of the river; and by the Farnley Beck and Hol-beck on the south side. The rainfall averaged during the last fifteen years 23 inches per annum. The smallest fall was 15·21 inches in 1865, and the highest 40·65 in 1872.

The district at present sewered comprises the townships of Leeds, Hunslet, Holbeck, and St. John's Wortley, and on an area of about 4900 acres contains a population of about 245,000 inhabitants.

The townships of Headingley-cum-Burley, Kirkstall, Chapel-Allerton, Potternewton, Armley, and Bramley, will shortly be sewered and united with the Leeds system of sewers, but the drainage of the townships of Beeston, Farnley, and other remaining portions of the borough, will probably be separately disposed of.

The waterworks are in the hands of the Corporation, and consist of a pumping station on the river Wharfe, capable of delivering six millions of gallons per day; but a system of three impounding reservoirs is now in course of construction in the valley of the river Washburn, from which the town will be supplied by gravitation: two are completed, and the other is in progress. The present daily supply is 7¼ millions of gallons. There are about 8500 water-closets, a small number for the population, as privies are chiefly provided for cottage property.

In 1842 the question of constructing a proper system of main drainage was entertained by the Corporation, and in December, 1842, Captain Vetch furnished a plan and report. In 1844 Mr. Thomas

Walker, the then Borough Surveyor, made a report on the drainage of the west end of Leeds.

Mr. J. W. Leather propounded an extensive scheme in an elaborate report, dated February 10, 1845, which was criticized in a report by Mr. Thomas Wicksteed, dated November 20, 1848; and Mr. Leather furnished a supplementary report, being a rejoinder to Mr. Wicksteed's comments; this was dated December 12, 1848.

In the year 1850 the contracts for the main sewers, according to Mr. Leather's scheme, were let, and the works proceeded with and completed in 1855; since then numerous sewers have been, and are being, continually laid, the total length being about 130 miles, and their total cost to September 1, 1875, having been 283,266*l*.

The outfall for the whole of the sewage is in the Thorp Mill Pool of the river Aire, at Knostrop, two miles and a quarter from the Town Hall; it terminates for a length of 1550 yards, 8 feet wide by 7 feet 9 inches high, and having a gradient of 1 in 1634.

Beyond the works the effluent and storm waters are discharged into the river through an open channel of about 300 yards in length.

The chief part of the sewage of the borough having thus been brought to one outfall in 1855, complaints began to be made that a serious nuisance had been created; the committee appointed by the Corporation therefore considered what means had best be adopted to purify and deodorize the sewage, and in order to obtain information as to what had been done in other places, in the year 1867 visited Worksop and Croydon. Mr. Edward Filliter, C.E., of Leeds, was then instructed to investigate the subject, and to procure all necessary surveys and levels, and to report what, in his opinion, would be the best course to adopt. In September, 1868, he reported that about 6000 acres of land for irrigation purposes could be obtained at Thorne Waste, a tract of sandy country absolutely barren, which land might also be used by Bradford and Wakefield, and that the warping channels on the border of Thorne Waste would transmit the purified sewage water direct into the tideway. The length of conduit required would be 27 miles, and he estimated the cost of the conduit with three iron aqueducts, and the purchase and laying out of 2000 acres of land, to be 258,000*l*. The sewage would flow to Thorne Waste by gravitation in about twenty-four hours, the conduit having a fall of 16 inches in a mile.

If the method of deposition was adopted, Mr. Filliter recommended a site for the construction of tanks near Waterloo Dam, on the river Aire, and he estimated the cost of extending the sewer from the present outfall to Waterloo Dam and the formation of the tanks to be 34,600*l.*; he also recommended that experimental works should first be constructed at Knostrop, adjoining the outfall.

In 1869 the Committee visited London, Hertford, Rugby, Bradford, and Harrogate; and in 1870, Birmingham, Coventry, Leamington, and Stroud.

In the early part of 1870, the Corporation having proposed to sewer the out-townships, the riparian landowners below the sewage outfall became alarmed, and in March of the same year took proceedings and obtained an injunction restraining the Corporation from causing or permitting the sewage of the borough of Leeds, or any part thereof, to flow into the river Aire until it had been sufficiently purified and deodorized as not to be, or create, a nuisance, or become injurious to the public health.

It was now absolutely necessary to take immediate steps to purify the sewage, and the Committee determined to make trial of the process of the A B C, or Native Guano Company, as it appeared most likely to properly purify the sewage, and give some return for the expense by the sale of the manure, and in August, 1870, entered into an agreement with that Company, of which the following is an abstract: "The Corporation to purchase the land required for the works, and grant a lease to the Company for twenty-four years; the Corporation to at once construct works capable of purifying two millions of gallons of sewage per day, the cost of these works not to exceed 6000*l.*, exclusive of land; and afterwards, if the purification is successful, to extend the works to enable the Company to purify twelve millions of gallons per day, at a further cost of 14,000*l.* If the Company made any profit, then they pay to the Corporation 5 per cent. upon the cost of the works, exclusive of land, beyond this if any profit remained, 15 per cent. to be handed over to the Corporation. The works to be carried out from the plans and specifications provided by the engineer to the Native Guano Company, and the Company to be paid 2½ per cent. for such plans and specifications."

The Corporation immediately purchased the land, and performed their part of the agreement, by erecting the first portion of the works now known, as the Experimental Works, which consisted of

a tank of brickwork 180 feet in length, 28 feet in breadth, and 12 feet in depth; it contained at its working level about 336,500 gallons of sewage; it was sunk almost entirely in the ground, so that the sewage, when dammed back by stop-planks across the sewer, could flow into it, such of the effluent as could not obtain a natural outfall being pumped by a centrifugal pump when the tank required to be cleaned. Whilst the sewage was being pumped the effluent water ran over the top of two sluices, acting as a weir, and then flowed through earthen pipes to the outfall. At the entrance end of the tank was an agitating chamber through which the sewage passed, and on either side of it was an A B C mixture pit, each being supplied with an agitator. The machinery consisted of a grinding mill with 6-foot revolving pan, with rollers 3 feet in diameter and 10 inches in width; a set of three-throw mud pumps, each with 10-inch barrel and 23-inch stroke; a centrifugal pump for removing the effluent water, capable of lifting about 5000 gallons per minute to a height of 15 feet; and a wrought-iron mud tank.

The machinery was driven by a 20 horse-power horizontal steam-engine, and steam supplied by two Lancashire boilers, each 30 feet in length and 6 feet 6 inches in diameter.

There were also four drying sheds and manure stores, and the Company afterwards put up two small drying cylinders.

The permanent works as completed, with the various additions to the original contracts and as now in use, consist of a grating tank, engine and boiler houses and chimney shaft, mill house, warehouse, lime shed, twelve depositing tanks, and a shallow reservoir or pond, about 5 acres in area, the mud pump, mud tanks, and drying cylinders.

Engine House, &c.

The engine house contains two horizontal steam-engines, each having two cylinders of 16 inches diameter and 2 feet 6 inches stroke. These drive by means of belting two of Gwynne's No. 14 centrifugal pumps, each having two suction pipes 18 inches diameter, and a 24-inch delivery pipe. A similar pump driven by an engine combined with it has been recently added, and is kept in reserve in the event of any accident occurring to either of the engines or pumps.*

* These pumps, from experiments made, each throw about 9000 gallons per minute at ordinary speed of working, with a lift of 18 feet.

The delivery pipes from the three pumps are all united into one of 3 feet diameter. There is a sluice across the sewer below the pumping well to head up the sewage and prevent its passing until purified. Two of Tangye's special pumps supply water to the tank on the top of the mill house. A horizontal engine of 20 horse-power drives the machinery and hoists materials; it has a cylinder 16 inches in diameter, with a stroke of piston of 3 feet 6 inches. Steam is supplied by four Lancashire boilers, each 30 feet in length and 6 feet 6 inches diameter. About 10 tons of slack coal are consumed in twenty-four hours to furnish steam for all the above. The chimney shaft, which is circular, is built large enough to receive the smoke from the drying cylinders and machinery for driving them, as well as from the present boilers; it is 150 feet in height, the flue being 11 feet in diameter at the bottom and 8 feet diameter at the top.

Mill House.

The mill house is erected between the engine house and the tanks; it is three stories in height, and covered in with a cast-iron tank to contain water for mixing the ingredients used for the purification of the sewage.

The upper floor is partly used as a storeroom, and contains a grinding pan for crushing the alum cake.

The next floor is occupied with three grinding pans, each 6 feet in diameter, with revolving rollers 4 feet diameter, 1 foot 3 inches in width, and one revolving pan, 6 feet diameter with rollers 3 feet 3 inches diameter and 1 foot 2 inches in width.

An alum tank, made of oak, and provided with a wooden revolving shaft, with wooden agitators fixed to it for the purpose of keeping the alum solution well mixed. The alum is supplied in the required quantity by means of a lead pipe communicating with the delivery pipe of the pumps. Upon this floor the various ingredients, such as lime, clay, carbon, &c., are mixed, and after being thoroughly incorporated are allowed to fall into three large and two small wrought-iron boiler-plate tanks, which are fixed in the lower floor.

The three large tanks are each 10 feet in diameter and 7 feet 6 inches deep, each provided with a wrought-iron revolving shaft, with arms to prevent the heavy ingredients settling at the bottom. The two small tanks are each 4 feet in diameter and 7 feet 6 inches deep;

they are each also provided with agitators. All the five tanks have outlet pipes and sluices, so that the quantity of ingredients required to be mixed with the sewage, and which are constantly varying, can be readily regulated. It was at first arranged that the ingredients should enter the delivery pipe of the pumps, and an agitator was provided within it, but it was found better to let them flow along a trough to the feet of the pumps, where they mix with the sewage in the pump-well, and the whole is thoroughly incorporated as it passes through the pumps into the depositing tanks.

The warehouse adjoins the mill house, and is also three stories in height, provided with a hoist, by means of which the ingredients are taken to the two upper floors, either of the mill house or warehouse.

As large quantities of lime are daily used, it has been necessary to erect a store for it, and in this it is slaked so as to be ready for use: this building has a communication with the warehouse.

A siding has been laid from the railway, and a weighing machine placed on it, so that the lime, alum, coal, and other materials can be weighed in the railway trucks.

Depositing Tanks.

The tanks in which the sludge is precipitated are twelve in number, arranged six on either side of a double central channel; they are constructed in the usual manner of water tanks, with concrete foundation, clay puddle banks and floors, and the sides and bottoms pitched with 8-inch Bradford sets.

Eleven of the tanks are each, at the water level, 100 feet in length and 60 feet in width, and the twelfth is 88 feet × 60 feet; the depth of each varies, but the average depth of the whole is 6 feet. Each tank is divided from those adjoining it by a brick wall coped with stone, the top of each coping being 2 inches lower than the one behind it, so as to give a draught to the flow of the sewage through the tanks. Shortly after the works had been in operation, it was found that after all the tanks were full, the sewage then pumped appeared to flow in a thin sheet over the stagnant and subsiding sewage in the tanks, so that the full advantage of them was not obtained; to obviate this two cross walls were built in Nos. 3 and 7 to the full height of the sides of the tanks, but with eight openings at the bottom, 4 feet × 2 feet 6 inches; by

these the sewage was forced downwards and upwards, and the mixing more satisfactorily accomplished.

There are sluices across the top of each division wall, and on part of the sides next the central channel, and also across the central channel, so arranged that when it is necessary to isolate any tank for the purpose of removing the sludge, this can readily be done without stopping the pumping of the sewage through the remaining tanks. Beneath the centre channel is a subway 6 feet in width and 5 feet 8 inches in height; in this is a cast-iron pipe 18 inches in diameter, with 12-inch branch pipes communicating with each tank, and terminating with a sluice connected with a pipe resting on supports fixed at the level to which the top of the sludge is allowed to accumulate. When it is necessary to clean a tank, the sluice is opened and the water run off into the sewer to be again treated. When this water has run off, another sluice, 24 inches in diameter, situated at the lowest corner of the tank, is opened, and the sludge is swept through it and a pipe communicating with the subway. The sludge then partly flows, and is partly swept along the subway to its termination in a well, from whence it is pumped by a special pump and engine made by Tangye, of Birmingham. The steam cylinder is 14 inches diameter and stroke 24 inches, and the pump 12 inches diameter, with 24-inch stroke. The sludge is lifted about 16 feet, and then flows along movable wooden shoots into one of the eight mud tanks, which are merely formed with earthen banks. In these the water drains off, and the sludge becomes of about the same consistency as brick-earth when ready for moulding; it is then turned over and cut into blocks, and left further to dry, so that when taken to the drying cylinders there shall be as little moisture as possible.

The twelve tanks have a united water area of 71,270 square feet, or about 1¾ acre, and contain 2½ millions of gallons.

The first four tanks are cleaned out about every five days, and the fifth and sixth about every seven days. The remaining six tanks scarcely require cleaning, the deposit never being above about 1 inch, but they are emptied four or five times a year to change the water.

When ready for cleaning, the mud in No. 1 would average about 21 inches deep; in No. 2, 18 inches deep; in No. 3, 10 inches deep; in No. 4, 6 inches deep; in No. 5, 5 inches deep; in No. 6, 4 inches deep.

After the tanks had been a short time in use, it was evident

that although the sewage in its passage through them deposited by far the greater part, if not all, of the solids, yet a much greater purity of the effluent could have been obtained if the area of the tanks had been greater. There was a space of about five acres between the new and old works, and this was at once embanked and formed into a shallow reservoir,* with a bank raised along the centre of the reservoir for nearly its whole length, so that the effluent now enters at one corner, flows all along one half, round the dividing bank, then along the other half, and finally flows off at the opposite corner from which it entered. This has been found an important addition to the works, and gives most satisfactory results. Upon the suggestion of Dr. Alfred Smee, a belt of osiers and another of reeds have been planted, and *Anacharis* thrown in; but at present no opinion can be formed as to the effect of these experiments.

When the tanks were first completed, the purified sewage flowed over the end wall of the last tank, and then down a flight of steps to the old outfall sewer, and thence into the river; but when the 5-acre reservoir was formed, it was necessary to provide means by which the effluent could be turned into it. The obvious method was to fix a sluice across the end wall, and make another opening, also provided with a sluice, on the side of the tank communicating with the pond, but this was objectionable, as a 50-feet gauge weir had been fixed on the coping, and also for other reasons. It occurred to the author to have a wrought-iron trough made, moving on rollers, and worked by racks and pinions; this was done, and in less than one minute the effluent can be turned either down the steps or into the reservoir, by either moving the trough from under the lip of the weir or placing the trough close to it. At the same time a foot-bridge was constructed alongside of it.

Machinery for Drying the Sludge.

To dry the sludge into a portable manure, four drying cylinders are now erected and at work, and four others are in course of erection; they are patented by Mr. Alfred Borwick, of London. Each cylinder is 6 feet in diameter and 16 feet in length; they are set in pairs in brickwork, and fired underneath from the sides. The cylinders are fed with mud at one end, and the mud, dried into

* This was suggested by Mr. Rupert Goodall, who was at the time experimenting at the works.

a powder containing about 25 per cent. of moisture, issues continuously from the opposite end. Inside each cylinder is a revolving shaft furnished with scrapers, which prevent the mud from caking and adhering to the hot cylinder, and thus depreciating the value of the manure, the scrapers also propel the drying mud towards the outlet end.

The cylinders are at present driven by a portable engine, but eventually, when it is found how many cylinders are absolutely required, a fixed engine will be provided. The cylinders make one and a half revolutions per minute, and can each produce 4 tons of dried manure in twenty-four hours, containing about 25 per cent. of moisture, at a cost for labour, power, fuel, &c., of 7*s.* per ton; this cost we expect to reduce by the introduction of machinery to take the sludge to the cylinders.

Sixty gentlemen have made trials of 1 or 2 tons each of the dried manure from the A B C process, and the effect on turnips, potatoes, general garden produce, and grass, is reported upon favourably by forty of them, and unfavourably by twenty; but some of these latter remark that the season was too dry for a fair trial to be obtained.

A manure merchant has lately agreed with the Corporation to take the whole of the manure manufactured from June, 1876, for twelve months, but I am not at liberty to mention the price to be paid.

The total cost of the works has been as follows:

	£	*s.*	*d.*
Land	5,196	0	0
Experimental works: new engine for ditto, and plant taken from Native Guano Company	10,799	7	6
New works: engines, boilers, and mill work, Gwynne's pumps, special pumps and mud pump, belting, &c., smoke-consuming apparatus, &c. ..	8,416	14	10
Precipitating tanks, engine and boiler houses, mill house and buildings, chimney shaft, sluices, grating tank, wrought-iron movable trough and bridge, gauge weir, 5-acre pond, and railway siding	24,886	3	4
Drying cylinders, shafting, and flues	4,407	16	6
Twelve cottages for men, offices and stores, gas and water pipes, fencing, paving, culvert to bring water from river, and drains	3,837	16	0
Total	£57,543	18	2

The number of men employed upon the works and their duties are as follows:

Time and book keeper	1
Engine drivers	2
Firemen	4
Foremen of mixers	2
Men in grinding room, in daytime	11
" " at night	7
Men slaking lime, taking materials to hoist, and cleaning tanks	6
Men attending drying cylinders, wheeling sludge and manure, &c.	7
Ditto, ditto, at night	7
Carpenter (repairing barrows, shoots, &c.)	1
Total	48

Having now briefly described the works, it may be interesting to review what has been done by the Leeds Corporation respecting the purification of the sewage.

As has been before stated, in 1870, the Corporation, considering that the process of the Native Guano Company offered the best means of purifying the sewage and obtaining some return for the expense by the sale of the manure, had entered into a contract with that Company, and performed their part of such contract in erecting the experimental works, in accordance with the plans prepared by the Company's engineer.

Accordingly, in the beginning of October, 1871, the Native Guano Company commenced to purify about 1,000,000 gallons of sewage daily, and they obtained, as I frequently saw, a very excellent effluent, bright and clear, and free from smell or taste. They continued doing this until the new works were nearly completed, but the expenses had been far greater than had been expected, and it was difficult to sell the manure at a remunerative price; moreover, the Company apparently feared to incur the large liability to which they would be exposed if they commenced treating the whole of the sewage at the new works.

As the management of the old works was entirely in the hands of the Company, I am not able to say what the purification really cost them; but from the best information I can obtain, the ordinary quantity of materials used to purify 1,000,000 gallons of sewage was:

	Tons	Cwts.	Qrs.	Lbs.
Alum	2	13	1	0
Carbon *	2	0	0	0
Clay	3	6	2	12
Blood mixture	0	0	2	0
Lime	0	1	2	18
Total	8	2	0	2

* The carbon is animal carbon, being refuse from prussiate of potash works.

Costing, say 7*l*. 5*s*. per million gallons; and if 9,000,000 gallons had been purified, the cost for ingredients would have been 2*l*. 16*s*. per hour.

According to Sir J. W. Bazalgette's report at Crossness, the ingredients used to purify about 12,000,000 gallons of sewage, in the months of August, September, October, and November, 1872, weighed about 166½ tons, and cost 293*l*. 16*s*. 10*d*., being at the rate of 24*l*. 9*s*. 8*d*. per million gallons, whilst at Leamington it cost 15*l*. 18*s*. per million.*

On the 14th March, 1873, the Company gave notice that they were not in a position to continue the working of the process and dealing with the sewage at Leeds, and after considerable discussion, the Corporation agreed to release the Company from their contract upon condition that they were allowed to use all or any of the Company's patents, free of royalty.

Accordingly, on the 1st of June, 1873, the Corporation took possession of the experimental works, and shortly afterwards invited any persons who wished to make experiments to do so, the Corporation lending the works and machinery free of cost, and the experimenters finding coals, labour, and the required ingredients.

In September and October Mr. Sylvester Fulda made a trial, and afterwards General Scott experimented, and showed that he could manufacture a very good cement from the sludge.

Mr. Rupert Goodall, of Armley, near Leeds, was the next to apply his process, combining the use of lime, animal carbon, ashes and an iron liquor, which he called sesqui-persulphate of iron. His experiment was so far successful that he formed a company, called the Leeds Clarifying and Utilization of Sewage Company, and in June, 1874, the Corporation agreed that Mr. Goodall's Company should work their process for three months; but as the new works were not ready so soon as was expected, the time was extended to a further period of three months from January 1, 1875, and the result of his experiments was that he produced a good effluent at a cost of about 16*s*. 6*d*. per hour *for ingredients* to treat the whole of the sewage of the town passing in that time, and taking this quantity at 9,000,000 gallons in twenty-four hours, the cost would be 44*s*. per million gallons.

* See a paper by Mr. W. Shelford, on the 28th March, 1876, read before the Institution of Civil Engineers.

The quantity of materials used daily to obtain the above effluent were:

	Tons	Cwts.
Lime	21	15
Carbon	13	15
Ashes	10	14
Iron liquor	0	4
Total	46	8

There is not any analysis of the effluent water answering to the above quantity of materials used, but at the experimental works in December, 1873, by the use of the following ingredients 800,000 gallons of sewage were treated, and an effluent produced which was analyzed by Mr. Fairley. The ingredients used were:

15 cwt. of lime.
15 „ of carbon.
1 carboy of iron liquor.

MR. GOODALL'S EFFLUENT ANALYZED BY MR. FAIRLEY IN FEB., 1874.

	Per Cent.
Mineral matters, consisting of chlorides, salts of lime, magnesia, alkalies, &c.	40·75
Volatile and organic matters	9·72
Total dissolved solid matter	50·47
Containing chlorine	7·93
Equivalent to common salt	13·11
Containing ammonia	0·574
„ albumenoid ammonia	0·30
Equivalent to nitrogenous organic matter about	3·00

The undried residuum contained:

	Per Cent.		Pounds per Ton.
Moisture	68·95	..	1544·5
Organic matter	5·65	..	126·6
Phosphate of lime	6·40	..	143·4
Sulphate of lime	2·38	..	53·1
Carbonate of lime	2·90	..	67·0
„ of magnesia	3·04	..	68·1
Oxide of iron	2·07	..	46·4
Alumina, alkalies, &c.	0·12	..	2·7
Siliceous matter	8·40	..	188·2
	100·00	..	2240·0
Containing nitrogen	0·13	..	2·91
Equivalent to ammonia	0·156	..	3·49

The Native Guano Company hearing that Mr. Goodall had found that he could purify the sewage in large quantities in the

new works at a much cheaper rate than at the old experimental works, were desirous to make trial to see whether they could not also cheapen their process. Accordingly, in June, 1875, they commenced working, and by making an alteration in their formula by reducing the quantity of alum and using a very much larger quantity of lime, they, in August, 1875, obtained a very good effluent, which was analyzed by the late Dr. Letheby, as follows:

CONSTITUENTS PER IMPERIAL GALLON.

	Grains.
Actual or saline ammonia	1·207
Ammonia derivable from organic matter	0·147
Nitrogen or nitrates	0·000
	1.354

In Solution.

Carbonate of lime and magnesia	13·70
Sulphate of lime	14·28
„ of magnesia	10·78
Alkaline sulphates	3·99
Chloride of sodium	11·79
Phosphoric acid	a trace
Organic matter	4·59
Total dissolved	59·13

In Suspension.

Organic matter	0·32
Mineral „	0·22
Total suspended	0·54

The amount of oxygen required for the oxydation of the organic and other oxydizable matters in solution was 1·28 grains per gallon.

Under the microscope the suspended (or insoluble) matters were found to consist of amorphous mineral matter, with filaments of sewage fungus and particles of vegetable tissue.

These results show that the effluent water is a good sample of defæcated sewage, and that if exposed to the air, instead of being corked up in a bottle for several days before I received it, it would have been inoffensive and admissible into a running stream which is not used for drinking purposes. It fulfils in fact the conditions required by the Conservators of the river Thames for the effluent water which is admissible into the river Thames below Teddington Lock.

(Signed) H. LETHEBY.

October 12, 1875.

Note.—Mr. Goodall read a paper before the members of our Association at the Annual Meeting at Manchester in July, 1875, and it is printed in vol. ii. of our Proceedings, p. 45.

The following analysis of the dried residuum from the process of the Native Guano Company was made by Professor Voelcker, June 2, 1876:

	Per Cent.
Moisture	24·53
Organic matter and water of combination	20·39
Oxide of iron and alumina	14·23
Phosphate of lime	1·66
Carbonate of lime	11·98
Sulphate of lime	1·88
Alkaline salts and magnesia	1·95
Containing ·45 of potash and insoluble siliceous matter	23·38
	100·00
Containing nitrogen	·43
Equal to ammonia	·53

The materials used per day of 24 hours to obtain this effluent and residuum were on an average of 9 days and nights:

	Tons	Cwts.	Qrs.	Lbs.
Lime	7	2	3	2
Animal carbon	6	1	0	4
Norris's alum	3	12	0	12
Clay	7	10	1	20
Carbolic sulphite *	0	0	0	27½
Total	24	6	2	9½

costing 21*l.* 19*s.* 5*d.*; equal to 18*s.* 3¾*d.* per hour, or taking the total daily quantity at 9 millions gallons, the cost would be 2*l.* 8*s.* 10*d.* per million.

In a subsequent trial made for a week in January, 1876, the following materials were used upon the average during each 24 hours:

	Tons	Cwts.	Qrs.	Lbs.
Lime	6	13	3	20
Carbon	8	6	0	24
Spence's alum	5	6	1	4
Clay	11	2	1	4
Carbolic sulphite	0	0	0	5½
Total	33	8	3	1½

costing 29*l.* 11*s.* 9*d.*; equal to 1*l.* 4*s.* 8*d.* per hour, or on a total daily quantity of 9 millions of gallons 3*l.* 5*s.* 9*d.* per million gallons.

* The powerful effect of this material was shown by the fact that although only a thin thready stream of liquor was allowed to flow into the sewage at the end of the delivery pipe from the pumps, if the hand was dipped into the effluent water at the last tank the smell of carbolic acid could be detected.

Towards the end of 1875, Mr. John Hanson, of Dewsbury, patented a process for sewage purification, and the Corporation arranged with him to try what he could do with the whole of the sewage; after several trials he succeeded with the following materials in producing a very good effluent. In 24 hours he used:

	Tons	Cwts.	Qrs.
Lime	20	0	0
Black Ash	4	0	0
Red Hæmatite and Double B.O.V.	1	6	2
Total	25	6	2

costing 20*l.* 11*s.* 2*d.*; equal to 17*s.* 1½*d.* per hour, or taking the total quantity in 24 hours at 9 millions of gallons, the cost would be 2*l.* 5*s.* 8*d.* per million.

An analysis of the effluent obtained from the above materials was made on the 1st April, 1876, by Mr. Thomas Fairley, the Borough Analyst, and is as follows:

It contains in grains per gallon:

	Grains.
(1) Mineral matter, consisting of chlorides, salts of lime, magnesia, alkalies, &c.	42·24
(2) Volatile organic matter	3·68
Total dissolved solid matter ..	45·92
(1) Containing chlorine	4·62
Equivalent to common salt	7·79
(2) Containing ammonia	0·40
,, albumenoid or organic ammonia ..	0·14
Corresponding to nitrogenous organic matter, about	1·40

Professor Voelcker's analysis of residuum from Mr. Hanson's process, June 2, 1876, is as follows:

	Grains.
Moisture	23·17
*Organic matter and water of combination	20·38
Oxide of iron and alumina	12·28
Phosphate of lime	·98
Carbonate of lime	26·86
Sulphate of lime	4·21
Alkaline salts and magnesia (containing ·26 of potash)	2·63
Insoluble siliceous matter	9·49
	100·00
*Containing nitrogen	·45
Equal to ammonia	·55

Mr. Hanson, from experiments since made, asserts that he can dispense with the hæmatite, and obtain an equally good effluent by the use of lime, black ash, and brown oil of vitriol, and consequently at less cost.

Towards the end of April Mr. Hanson's process was discontinued, so that lime only, without any other ingredients, should be tried for a fortnight; this could not extract the dye from the sewage and the effluent was frequently mahogany coloured.

The Native Guano Company then applied to be allowed to experiment with a cheaper description of alum made by Messrs. Spence, of Pendleton, and these experiments are still (July, 1876) in course of progress.

It will thus be seen that the three processes just described are chiefly dependent upon lime, but with the addition of alum, carbon, iron, and acid, principally to destroy the colour from the dye.

It must be noted that the Native Guano Company in other places (chiefly water-closeted towns), and in their earlier experiments at Leeds, where, as has been stated, there are but few water-closets, used little lime but a very much greater quantity of alum. At Aylesbury, a water-closeted town, they are now (July, 1876) using to purify one million gallons

	Tons.	Cwts.	Qrs.	Lbs.
Alum	1	17	0	0
Clay	2	14	1	0
Blood	0	1	0	14
Charcoal	1	4	0	0
Lime	0	4	1	19
Total	6	0	3	5

In addition a small quantity of carbolic sulphite is used.

The process to be ultimately adopted will probably be determined by the value of the manure obtained.

Before concluding, it will perhaps be useful to append a few notes descriptive of the quality and quantity of the sewage.

Leeds Sewage.

The quality of the sewage of Leeds is rather poor, as will be seen by the following analysis, but it contains refuse from tanneries and dye works which occasionally colour it so as to make it almost red, and it is this colour which experimenters find so much difficulty in destroying, but as nearly all the streets are paved very little road detritus arrives at the outfall.

On the 30th April, 1870, the late Dr. Letheby analyzed the Leeds sewage, and compared it with that of Leamington and London, as follows:

Constituents per Imperial Gallon.	Leeds, March, 1870.	Leamington, Dec., 1869.	Average London Sewage.
In Solution:			
Ammonia ready found	1·120	2·543	6·60
" in organic matter	0·184	0·220	
Organic matter	9·69	14·43	15·08
Chloride of sodium	15·36	11·04	17·97
Oxygen required to oxydize	0·941	1·830	..
Total matter in solution	61·77	66·13	55·74
In Suspension:			
Organic matter	6·78	39·92	16·11
Mineral matter	5·46	73·68	22·04
Total in suspension	12·24	113·60	38·15
Total dissolved and suspended ..	74·01	179·73	93·89

The results show that the sewage of Leeds is not so highly charged with ammonia or dissolved organic matter as the Leamington and London sewage, and that the suspended matters are very small in quantity.

(Signed) HENRY LETHEBY.

The late Mr. J. Chapman Wilson, of Leeds, and Chemical Professor to the School of Medicine, also made an analysis of a mixture of 42 samples of Leeds sewage, taken between the 21st and 28th November, 1868, at midnight, 4 A.M., 8 A.M., 4 P.M., and 8 P.M. of each day; the result was:

An imperial gallon contained:

	Grains.
Fixed salts in solution	50·54
Organic and volatile matters, in suspension	11·20
" " in solution	15·68
Total solid matter	77·42

As to the daily flow of sewage at Leeds, Mr. Filliter, in November, 1869, estimated it to be about 9⅓ millions of gallons in 24 hours, flowing at the rate of from 15 to 16 millions in the daytime, and 5 to 6 millions during the night, and it somehow became assumed that the dry-weather flow was now about 12 millions of gallons in 24 hours, but a proper gauge, 50 feet in width, has been fixed on the end wall of the last tank, and from several trials lately made it

is found that the quantity is really only about 9 millions of gallons in 24 hours.

In times of slight rain the flow increases to the rate of 24, 29, 38, and 45 millions of gallons per day; and after a morning of really heavy rain Mr. Filliter found the flow to be at the rate of 110 millions of gallons per day.

One of the centrifugal pumps generally is able to pump all the sewage, but from 10 A.M. until about 1 P.M., and from 3 P.M. until 6 P.M. two pumps are required; on the other hand, during the night there is not enough sewage to supply one pump, and the engine is generally stopped to allow the sewage to back up in the sewer from 9 to 10 or 10 to 11 P.M., and again stopped from about 2 A.M. until 3.30 or 3.45 A.M.

ON THE REMOVAL OF EXCREMENTITIOUS MATTER IN TOWNS IN CONNECTION WITH SEWAGE DISPOSAL.

By EDWARD BUCKHAM, Assoc. Inst. C.E.,
Borough Surveyor, Ipswich.

The subject of the collection and treatment of the refuse of towns in connection with the general question of sewage disposal, has of late had considerable attention given to it, and it is now I believe fully admitted that there are a large number of towns where the conditions are such, and the difficulties of disposing of the sewage so great, that it necessitates, in connection with sewerage, the collection of solid excrementitious matter on what is generally known as the dry system.

The character of a town to a large extent must decide the best way of disposing of its refuse. There are some towns where it would obviously be desirable to have an entire water-carriage system; for instance, such towns as Leamington, Cheltenham, Hastings, Brighton, &c.; but there are others where it would be equally obvious, having regard to local circumstances, that some improved system of collecting excrementitious matter on the dry system would be advantageous, as for instance, such towns as Manchester, Birmingham, Nottingham, Rochdale, Halifax, Ipswich, and others. Notwithstanding the many advantages of the water-carriage system, it is most improbable that towns such as just referred to, will ever be made entire water-closet towns, containing as they do such a large proportion of the artizan class, occupying cottages. Then there appears to be other difficulties in the way of disposing of sewage by the water-carriage system. Experience has shown that sewage to be disposed of satisfactorily must be dealt with in one of three ways, either by irrigation, intermittent downward filtration, or by an elaborate plan of chemical treatment.

The disposal of the sewage of large towns by irrigation is in most cases rendered impracticable by reason of the difficulty in

procuring land, or from the enormous cost of erecting and maintaining pumping machinery, and this applies, although not to the same extent, to intermittent filtration, in cases where the lift is moderate, and where a large number of water closets already exist in a town, it is in my opinion a satisfactory way of purifying the sewage.

There are many cases where the levels of the surrounding district offer every facility for irrigation or intermittent filtration by direct gravitation. Croydon may be taken as an example, where such circumstances exist. Irrigation possesses advantages over all other modes for the utilization and purification of sewage, whether the entire sewage (liquid or solid) passes into the sewers or not.

Treating sewage by chemical agency, although to a certain extent successful, is most costly, and when dealing with sewage on a large scale by this means, involves a serious annual outlay for chemicals. Lime was one of the earliest chemical agencies employed for sewage purification, and for simple and economical treatment, where a high standard of purity is not essential, is still in the writer's opinion the best.

Having made this general reference to the sewage question, I now propose briefly to describe what has been done towards the drainage and removal of refuse in the borough of Ipswich.

I intend this paper to refer more particularly to the town of Ipswich, and although I wish more especially to direct the attention of the Association to the disposal of the solid rather than the liquid part of sewage, it will be necessary, to make myself properly understood, that I should give an account of all that has been done in the matter, so far as Ipswich is concerned.

Ipswich stands on the river Orwell, and is 12 miles from the sea, containing a population of 46,000. It is partly but indifferently sewered by a combined system of brick and pipe sewers, which discharge their contents at various outlets into the rivers Gipping and Orwell. These old and improperly constructed sewers suffice to take about one-third of the sewage, the remaining portion passing into what are locally termed "dead wells."

In 1857 the corporation directed their attention to the improvement and extension of the sewerage of the town, and instructed Mr. Peter Bruff, C.E., to examine into and report on the matter; accordingly in October, 1857, Mr. Bruff recommended the construction of an intercepting sewer on each side of the river Orwell

intercepting various outlets from discharging into the river in the central part of the town, and carrying the whole to a point called Pilots Hard, and discharging it (after passing it through tanks for partial purification) into the river Orwell, about a mile from the town.

Mr. Bruff's plan, however, met with considerable opposition, and after being much discussed by the council, the matter was substantially dropped till April, 1870, when the attention of the council was called by the dock commissioners to the accumulation of the sewage matter in the river which much impeded navigation. The council would not admit that the accumulations arose from sewage deposition; but without binding themselves in any way they consented with the commissioners to take the opinion of Mr. Coode (now Sir John Coode). His report, however, made in July, 1870, only resulted in the council agreeing to pay part of the cost of keeping the river clear by dredging, and the matter was continued till November, 1871, when I was requested to prepare a plan for an intercepting sewer, and to report on the practicability of utilizing the sewage by irrigation, or after treating it in tanks, to discharge it into the river. I gave my opinion in favour of Mr. Bruff's plan of 1857, which was to construct two low level sewers, one on each side of the river, intercepting and conveying the sewage to a point on the river called Hog Highland, for the north side of the town, and to a point known as Bourne Bridge on the south side, with provision at each outfall for tanks in duplicate for retaining as much of the solid matter as could be retained by simple subsidence and screening. There was still considerable difference of opinion as to the mode of disposal, some contending that the sewage after being thus treated might be discharged into a tidal river like the Orwell with impunity, while others looked upon it as most objectionable.

In March, 1872, Mr. Bailey Denton, C.E., was instructed to report "on the best means of sewering the town of Ipswich, particularly with regard to the ultimate disposal of the sewage." In July, 1872, Mr. Denton made his report, recommending the construction of an outfall sewer, similar in its position and direction to that adopted by Mr. Bruff, but proposed to connect the Stoke side of the town with Ipswich, and concentrate the whole of the sewage at one point of outfall, and advised wide irrigation associated with intermittent filtration. Mr. Denton's scheme, while perfectly practicable, and with a reasonable probability of the returns from a

sewage farm paying cost of pumping, &c., was not very favourably looked upon, on account of the largely increased first cost over a gravitating scheme, and the annual cost of maintaining the pumping station, &c., as well as by the increased difficulties in constructing the intercepting sewer, by reason of its being, as Mr. Denton proposed, at a much lower level to provide for the basement drainage of a limited number of houses along its course.

There being still an opinion in favour of a gravitation scheme, sending the sewage direct into the river, after some simple treatment to retain the more solid part it was suggested that the opinion of Dr. Voelcker should be taken upon Mr. Denton's report, particularly with reference to the effect of the sewage upon the river. In November, 1872, he reported that he was of opinion, after an analysis of the sewage, and an examination of the land proposed as an irrigation farm (which he characterized as "miserably poor gravelly soil"), that in an economical point of view it would turn out to be a gigantic failure. Having taken carefully into account the circumstances connected with the construction of a main intercepting sewer in Ipswich, he had not the slightest doubt that the cheapest and most effective mode of disposing of the sewage nuisance of Ipswich would be to send it bodily direct to sea with the flow of the receding tide. The bulk of water into which the sewage would be discharged appeared so large, and the flow of the tide so great, that the apprehension of the sewage being returned to Ipswich by the returning tide, and forming a deposit on the fore shore, would not be verified by actual experience, and he did not share the opinion which was sometimes expressed that sewage discharged into sea water becomes peculiarly offensive, and he stated that the sewage might be discharged into the Orwell at the point proposed by Mr. Bruff without creating any nuisance by the supposed deposition of mud on the river banks. This brought a reply from Mr. Denton, in which he endeavoured to substantiate his statement, that if the sewage were discharged by a gravitating sewer with the outlet, level with half-low water, as proposed by the gravitating scheme, it would inevitably return to Ipswich by the succeeding flood-tide, and would contaminate the banks of the river, which, at low water, when exposed to the sun, would be offensive, as had been shown by experience to be the case in other towns similarly circumstanced.

The general feeling was in favour of Mr. Bruff's gravitating scheme for the disposal of the sewage, and he was directed in

February, 1873, to furnish an estimate of the cost of carrying out his plan, making provision for such straining, filtering, and precipitating, as he might deem necessary for arresting the solid matter in the sewage. This was done in July, 1873, and the matter stood in abeyance till February, 1874, when a committee was appointed, not only to consider the question of surface and water-closet drainage, but also the question of removal of excreta, house refuse, offal, and other offensive matter, and to report to the council with a complete scheme for dealing with the whole subject, together with the cost of the same.

To dispose of the sewage of Ipswich, either by irrigation or by intermittent filtration, would be attended with considerable expense. The town is divided by the river Orwell, and as is frequently the case with towns so situated, the longitudinal falls are very slight while the lateral falls are very great, and it was found that to utilize the sewage by irrigation would require a lift of 130 feet, and for intermittent filtration 70 feet. To carry out either of these modes of disposal would involve a very large first outlay for pumping works and land, as well as the annual expense of maintenance.

Having regard to the conflicting statements of scientific opinion upon the best means of disposing of sewage, and the probability of sewage farming being a failure, it was considered to be advisable to avoid anything in the shape of costly experimental works, and it was decided to carry out a gravitating scheme, passing the sewage direct into the river, after some simple and economical treatment, such as clarification by lime, and at the same time reducing the amount of solid matter to be dealt with by discouraging water closets, gradually replacing the old privies and middens by improved ash closets, and by periodically and systematically collecting the accumulations from the same.

It then became a question, how this system of house to house refuse collection in connection with the drainage of the town could best be carried out. In a great many towns the refuse is collected from those houses not having water closets from the old privy and ash-pit, but the collection from the old ash-pit is so objectionable on sanitary grounds, that the continuation of such a plan for collecting the solid could not be entertained.

There are about 10,300 houses in the borough, of which not more than 850 are supplied with water closets, and therefore if the water-carriage system was to be discouraged there would be the

accumulations of 4000 middens or thereabouts untouched by the sewers.

As the contents of these middens were not to enter the sewers, and as the collection of the accumulations from them in their present form was considered to be so objectionable on sanitary grounds, it became an important matter for consideration, what kind of improved closet would in all respects meet the requirements of the case.

The committee to which this matter was referred, in conjunction with the medical officer and myself, devoted a great deal of time and attention to arrive at the most suitable kind of improved closet for use in Ipswich. We made inquiries of all the principal towns in England, and we had under our notice a variety of patent apparatus for dealing with excreta on what is generally known as the dry system; amongst others were Parker's earth or ash closet, Moule's, Moser's, and Green and Gibbons', but we were determined not to adopt any closet that had not been extensively used in a town by a sanitary authority with a reasonable amount of success, or which did not show conclusively from its structural arrangements, that it would answer the purpose for which it was intended; from our inquiries we found that at Manchester, Salford, Nottingham, Halifax, and Rochdale a system of collection was being carried on from improved closets, which was reported as successful. The sanitary authorities being anxious to know the details of the system in each town, and to be able to form a definite opinion which of all those in these towns would be the most suitable to Ipswich, deputed the medical officer of health and myself to visit them and report our opinion of the different plans professing to deal successfully with the collection of house refuse, and which would be the most advantageous for general application in Ipswich; we accordingly visited and carefully examined into the systems in operation in Manchester, Salford, Rochdale, Halifax, and Nottingham.

It will not be necessary here, nor could I in the space of this paper, give a detailed description of the plans carried on in each town, but I will give a condensed account of each, more particularly referring to the Manchester and Salford closets.

The closet used in Manchester may be termed the cinder-sifting ash-closet. It consists of a building similar in appearance to a common privy, but arranged inside with two receptacles, separated by a wall: the receptacle for the excrement is a circular galvanized iron pail, 17 inches in diameter and 13 inches deep; that for the

garbage is about 1 foot 9 inches square and 13 inches deep, made in different sizes according to requirements. The cinder sifter is made in a small and convenient form, in the shape of an oblong box, and fixed in a vertical position, either at the side or rear of the seat, but as a rule it is built in the side wall, and arranged at such a level that the shoot for delivering the fine ashes on the excrement comes just above and in the centre of the receptacle. The ashes are put in through a sloping door at the top, as shown in the accompanying plan, and the sifter is so arranged that the fine ashes pass down an inclined shoot into the excrement receptacle, the cinders passing into a small chamber at the bottom, from which they are taken out and re-used as fuel.

The cost of erecting a new closet is, I believe, about 5*l.*, and for converting an old midden privy into an improved closet 4*l.* The receptacles cost 12*s.*, and are supplied by the corporation. At the time we visited Manchester, we understood there were 12,000 of these closets in operation, and that the old middens were being rapidly converted to the new system. For the purpose of collection the city is divided into districts, and especially covered vans and plant are provided for collecting the receptacles. The excrement and refuse collected undergoes a process of manufacture, and is converted into a dry portable manure, and at the time of our visit sold at 12*s.* 6*d.* per ton.

The closet in use at Salford is Morrell's patent self-acting cinder-sifting ash-closet. It is similar in principle to the Manchester closet, but instead of the sifter being at the side, it is at the back of the seat, and inside the closet, the cinder refuse is put on to the sifter through a small door in the side. The screener, which has a hopper attached to it, is acted upon by a lever in connection with the seat. When the seat is depressed by the person using the closet, it communicates a motion to the hopper which separates the ashes from the cinders; the ashes fall into the hopper, and are conveyed into the receptacle each time the closet is used; the sifted cinders at the same time pass down at the back of the sifter on to the floor of a chamber ready to receive them, from which they can be taken out and re-used. The receptacle pail is 19 inches diameter and 19 inches deep. It is larger than those used in the Manchester closet, and does not require emptying so often.

The mode of collecting and manufacture of manure is the same as at Manchester. The garbage box, instead of being inside the

building as at Manchester, stands in a corner of the yard. I understood the cost of a Morrell closet at Salford to be about 5*l.* complete, and there are 1000 in use in the Pendleton district of Salford. The receptacles are emptied about once in seven or ten days, and oftener if required.

At Rochdale, the plan of collection carried out is known as the "Rochdale, or separate system," and was introduced by Alderman Taylor of that town. The principal difference between the closets in use at Rochdale and those in Manchester and Salford, is, that the former have not any self-acting cinder-sifting arrangement. The fæcal matter and dry refuse are collected separately, the fæcal matter being removed without any admixture of ashes to absorb or deodorize it. When the receptacles are removed, a tight-fitting lid is placed on them to prevent any smell that might arise when removing the pails. There are, I believe, between 4000 and 5000 closets in use in the borough. For the convenience of collection the town is divided into districts, and each closet numbered. The dry refuse and excreta collected are converted into a dry portable manure.

At Halifax the old middens have been superseded by what is known as the "Goux closet." The arrangement of the closet is similar to the Rochdale, or separate system; there being two receptacles, one for the excreta, and the other for ashes and refuse. The receptacle for the excrement before being sent out is lined round the sides and bottom with an absorbent material. The mode of putting it in is by placing a mould inside, leaving a space of about 4 inches between the mould and outside of receptacle; this space is filled in with an absorbing material, which appears to be dry street or shop sweepings and factory waste, to which is added a percentage of sulphate of lime; this is pressed down, and when the pail is placed in the closet the mould is withdrawn.

The advantage claimed for this plan is, that the absorbing medium takes up the urine, prevents fermentation, and greatly facilitates the convertion of the excreta into a portable manure. The ashes with this system do not form part of the manure. The mode of collecting is similar to the other towns described.

At Nottingham the old midden system has been partly superseded by improved privies and what is known as the pail closet. The improved privy consists principally of being a circular-shaped ash-pit, properly constructed in cement, and made impervious, with

the roof carried over it to keep out rain water. This keeps the contents dry and prevents fermentation, at the same time means are provided for ventilation.

The pail closet consists simply of a movable tub, 19 inches in diameter and 17 inches deep. This is placed under the seat and receives not only the fæcal matter, but the cinders and vegetable refuse are put in, the seat being made to lift entirely up for the purpose. The riser is made to slide in a groove, so that it can be easily removed when the tub has to be taken out. When they are built in blocks of three or four, an extra tub is provided for garbage and ashes in a centre compartment or at the end, according to circumstances.

After a very careful consideration of the systems we had examined into, the medical officer of health and myself came to the conclusion that the ash closet as used at Manchester, or Morrell's closets as used in Salford, were the most suitable for adoption in Ipswich, because they were self-acting, not dependent upon the user for their efficiency, and used up the ashes for deodorizing purposes that would otherwise have to be provided for in a separate receptacle if they were not disposed of by the closet.

Upon this recommendation the sanitary committee decided to construct a few of these closets in the worst localities of the town, so that they might be put to the severest test. Eight of the Manchester and three of the Morrell were accordingly erected. The working of them was carefully watched for some time, extending over about twelve months, and it was eventually decided upon by the committee to recommend for general application the Morrell and Manchester closets, giving the decided preference to the Morrell.

They are gradually coming into use in the town, but the plan has not yet been sufficiently developed in Ipswich to enable me to give any particulars of the cost of working, or to state precisely the sanitary results.

According to a statement made by Mr. G. W. Pearse, at the Society of Arts, the financial result is most satisfactory, the Corporation of Salford making a profit of 1475*l.* per annum on the refuse of 1000 closets; and Dr. Tatham, the medical officer of health, speaks very highly of their sanitary efficiency.

I must confess I was a long time before I could roconcile myself to this mode of dealing with the solid part of sewage; but where

conditions exist similar to those of Ipswich, it appears to be the only way of getting out of the difficulty, and I am of opinion that by some simple treatment of the liquid sewage at the outfall, and a systematic collection of solid refuse, the requirements of Ipswich will be sufficiently provided for.

In treating such an important subject as the disposal of the liquid and solid refuse of towns, I neither wish to extol or depreciate either one system or the other. My object is to lay before you the facts as they have presented themselves to me, and give you the result of my investigations into this matter, with a view of eliciting the result of your experience upon one of the great questions of the day, "How to dispose of sewage?"

ON THE CONSTRUCTION AND COST OF SEWAGE WORKS.*

By THOS. W. GRINDLE, Assoc. Inst., C.E., Borough Engineer, Hertford.

It generally occurs that works for precipitation processes are in a low-lying situation, seldom allowing a depth of liquid of more than 4 or 5 feet between inlet and outlet from tanks, if the effluent is to be drawn off by gravitation.

Again, necessarily, the size of the tanks depends upon the purpose for which the sewage is intended, as well as the special process to be adopted; for instance, I have constructed precipitating tanks at Hertford (such as I judged to be of the proper capacity) to carry on the lime process; but I afterwards found the Phosphate Sewage Company's process, now in operation there, required but three-fourths of that capacity, and this Company obtain as good an effluent from the smaller precipitating area as was originally obtained from the larger area under the lime process. From this, I believe that under the Phosphate Sewage Company's process albumenoid matter coagulates much more quickly than under the lime process. I have also observed a similar rapidity of coagulation over the lime process in the native guano (or "A B C" process) and that of M. Hillé; but of their relative merits I do not purpose speaking.

When only simple subsidence is required, preparatory to the effluent being used for irrigation purposes, much smaller tanks are necessary, as, indeed, half an hour's quiescence is sufficient for the grosser particles to subside, and the sooner it is then applied to the land the less nuisance is caused, while the lengthened storage of sewage greatly deteriorates its value for agricultural purposes from the old sewage, communicating decomposition to the fresh as it enters the tanks.

The Hertford tanks are six in number, each 120 feet long, 20 feet wide, and 4 feet 6 inches deep; this gives a capacity of 67,500 gallons for each tank, four of which are constantly re-

* For Plans, see Appendix.

ceiving sewage and delivering effluent, during which time the fifth is being cleansed of the sludge or deposit, and the sixth being kept as a receptacle for storm water.

I find the six narrow tanks far preferable to two larger ones of the same area. I am thus enabled, during storms, at the time when most required, to utilize five-sixths of the settling area, while cleansing the remaining tank.

The quantity of sewage and subsoil water flowing from Hertford is equal to 700 gallons per minute, this under the lime process gave three hours and three quarters for the passage of the liquid through the tanks, or that time for precipitation.

The division walls of the tanks are two and a half bricks in thickness, outer walls two bricks thick.

The rule that I adopted to ascertain the proportion of the division wall is by estimating only the weight of the material of which the wall was constructed, to resist the pressure of water at its maximum height; as no dependence can be placed upon the cohesion of the materials it should be taken only as a bulk of material of sufficient weight to resist the pressure of liquid thrown against it.

I think the following formula, taken from a paper read at the Institution of Civil Engineers, by Thos. Dawson Ridley, Esq., but somewhat altered in terms, is about as accurate an one as may be thoroughly depended upon.

In estimating the pressure of the water to be resisted and the requisite strength of the division wall or partition, the following calculations may be used:—

P = the pressure of the water in lbs. to be resisted.
d = the depth of water = 5 feet.

Taking 62·5 lbs. as the weight of a cubic foot of water,

$$P = \frac{62 \cdot 5\, d^2}{2} = \frac{125\, d^2}{4} = 781 \cdot 2 \text{ lbs. per lineal foot of wall}; \quad [1]$$

$$M = \text{the moment of water tending to overthrow wall} = P \times \frac{d}{3};$$

$$\therefore M = \frac{125\, d^2}{4} \times \frac{d}{3} = \frac{125\, d^3}{12} = 1302 \text{ lbs.} \quad [2]$$

Let W = the weight of a cubic foot of the wall, which may be taken at 105 lbs. for brickwork;
h = the height of the wall above the invert = 5 feet;
t = the thickness of the wall, 2′ 3″;
D = the moment of the wall to resist overthrow.

$$D = \frac{h\, t^2\, W}{2} = 1328 \cdot 95 \text{ lbs.} \quad [3]$$

For safety D should exceed M.

The side walls of the tanks should, without exception, be kept upright, as battered walls impede solid particles in falling to the bottom. Again, many engineers, for the sake of neatness of workmanship, will specify a *ruled joint;* it is far better to have a *plain struck* joint, this giving it the smoother surface, or if expense be no object I should recommend to render and trowel the same over with Portland cement.

In one case I may mention, where the brickwork of the tanks was completely dry, I had both walls and bottom tarred; this prevented to a great extent the accumulation of sewage fungus, whereby the labour of sweeping down the sides at each emptying of the tank is reduced to a minimum.

In all cases where practicable, tanks containing sewage should be covered, to prevent the heat of the sun from assisting decomposition.

The deepest end of the tanks should, if possible, be near the point of entry, and at this deepest end a junction, with a sump common to all the tanks, into which the sludge can be swept, and thence elevated to the drying beds.

Some years back I found that there was not a complete admixture of the chemicals with the sewage upon its entry into the tanks. I designed a modification of an agitator similar to one I had seen in chemical works for washing gases. It consists of a chamber of rather more than the area of the inlet sewer, with boards placed at proportional distances; each alternate board is placed at the bottom of the tank, rising to a given distance therefrom, the other boards are placed at the top of the tank, dipping a given distance in the sewage, thus giving an up and down motion to the sewage, and thereby causing a thorough admixture; this answers admirably, there being little or no heading back of the sewage in the main sewer. See Drawing No. 3.

I have also seen an adaptation of this arrangement at the Institute of Civil Engineers, in the cartoon on a paper read by Mr. Shelford.

I now come to the elevating machinery (Drawing No. 3), which should be of the simplest possible description, such as may be readily worked by an unskilled labourer, these being the only class of people whom we may expect to conduct the operations in sewage works.

For instance, instead of an elaborate valve for closing the communication between the tank and the sump, I find that a plain

sheet of indiarubber compressed between two sheets of metal (Drawing No. 4) to be far superior, and effects a great saving, as all that is required to keep it clean and water-tight is simply an occasional brushing.

The method of elevating the sludge from the sump should be by the common dredge elevator (Drawing No. 3), that is, chain and bucket. I have used pumps, but have invariably found both cylinders and plungers very soon cut and scored from the gritty particles in the deposit, the valves also frequently choking.

The cost of constructing sewage tanks, of necessity, varies considerably with the locality in which they are constructed, therefore any general estimate I might give would not be reliable.

For instance, at Hertford the brickwork cost 14*l.* per rod; Buckhurst Hill, 17*l.* 10*s.*; Ponders End, 20*l.*; whereas at Hatfield, 12*l.* 10*s.* per rod was all that was paid to the contractor, so that you will readily perceive that I can but give you a rough idea. Another material to be taken into consideration in the construction of sewage tanks is concrete, for which, at Ponders End, I paid 16*s.* per cubic yard, at Hatfield only 10*s.* 6*d.*; but in the former case cement was 2*s.* 6*d.* per bushel, whereas in the latter it was only 1*s.* 9*d.*

The effluent, in all cases where it is not delivered upon the land prior to being sent into a stream, should undergo a course of straining or rough filtration (finely crushed coke I find the best for this purpose). There are particles in the sewage which cannot be acted upon by any known precipitant; these particles are really small pieces of sewage fungus, and in the event of not being detained by a strainer they pass away into the watercourse, attach themselves to the sides or bottom, and lead the uninitiated to suppose it to be actual sewage.

However unsightly as it may be, it has never been shown that it is injurious to the water, in fact the late Dr. Letheby assured me that under the action of light it lives upon what impurities there may be in the effluent; this statement I can personally endorse, as in the case of Hertford, where the water was found to have a higher standard of purity after it had travelled a thousand yards down the culvert than at the point at which it left the tanks.

Before concluding, I should like to make a few observations on a most valuable auxiliary to sewage works, and one that is too frequently overlooked by engineers, that is, the utilization at the outfall of the effluent water from tanks; and with this purpose I append

drawings of the Hertford Works, with the several details of sluices, machinery, &c., which I have had reduced in scale, so that they may be included with this paper.

At the Hertford Works the difference of level in the tail water of filters, which constitutes the head water of a water-wheel (6 feet in diameter), and the tail water of the said wheel is only 3 feet 6 inches, that constituting the whole power necessary to drive the entire lime and chemical mixing machinery, besides driving a small Forbes' rotary pump to lift the lower stratum of water (about a foot in depth) from the top of the sludge to a height of 8 feet, that it may be run through the tanks again. This power also elevates the sludge from the sump to a height of 30 feet, to deliver the same into the drying beds.

The quantity of effluent water delivered per minute upon the water-wheel is 700 gallons or 7000 pounds weight. This only represents two-thirds of one-horse power, theoretically, or one-third practically.

This power drives the whole of the machinery. Thus it must be obvious to all that steam power can be entirely dispensed with in similar cases.

In other places, I have no doubt, there are equal facilities. At Birmingham I was astonished to see a large volume of water falling a depth of 5 or 6 feet, entirely unutilized, whereas by a judicious application it might be made to work, at least, *a portion* of the machinery that is now being driven by steam power.

DISCUSSION.

Mr. Monson said although there were a great many patents for sewage purposes, it would be found on investigation that they are not distinct processes, but merely variations of the same process. As every patentee declared that his process was successful, they might assume that the treatment of sewage was not a very nice matter, and in stating the proportions of chemicals to be used they might always say more or less. In the Lime Process, hydrate of lime was the only agent used at Birmingham, but the sewage of that town must contain a large quantity of sulphuric and other acids, besides various metals, all of which assist in purification. The next process in point of simplicity was that of General Scott, who purified the sewage with lime and clay without the addition of any chemicals whatever, and this process had a distinctive method for disposing of sludge. He continued to describe the processes of Bird, Dr. Anderson, Forbes and Price's, Whitthread's, in the last named of which phosphate of lime was used and the precipitation finished with milk of lime. The phosphate was described as dicalcic phosphate dissolved in an aqueous solution of monocalcic phosphate. He did not know if these were commercial articles. The A B C Process appeared to him to include almost every other process; the ingredients used at different times were animal charcoal, clay, blood, and alum. There was no doubt that the ingredients, or some of them, used in this system would purify sewage, but the method of treatment must be varied to suit each town. It was now admitted on all hands that sewage had no commercial value, and towns must not expect to make a profit out of it; and again, sewage sludge was of no value. It would not pay therefore to put valuable soluble phosphates into sewage and bring them out in an insoluble state, and whilst in that condition quite useless as manure. The precipitation process of the future would therefore be lime only, and where greater purity was required, lime and sulphate of alumina with free acid. In the removal of excrementitious matter from towns, the first question for consideration had relation to health, the value of the material should not be thought of. The pail closets were opposed to every feeling of decency and refinement. Moreover the sewage had still to be disposed of, and therefore it was all

extra work. The water-carriage system was the cleanest, and he thought the most economical. This system should not be rejected because the sewage could not be purified. The only method for really purifying sewage was by removing the solids and then pass the sewage through aërated porous soil; but absolute purity was not required when the water was turned into tidal rivers. In any case precipitation must be resorted to. Mr. Monson was proceeding to quote a number of figures from the 'Journal of the Society of Arts,' for the purpose of showing the difference in the cost of the several systems of privies, but it appeared they did not bear upon the question.

The Hon. Secretary, speaking to Mr. Buckham's paper, said he could point the Association to the house of an eminent engineer in which there was not a water-closet to be found, and that gentleman entirely objected to them; however, upon this matter he (Mr. Jones) thought it was not right to draw a hard and fast line, as towns and places differed in circumstances. He did nothing but the water carried system, for there was great risk in being closely connected with the sewer.

Mr. Burstall said he had seen the pail system in operation at Rochdale, and he never heard of any real nuisance arising from it. Another advantage of this method was that the ashes were disposed of at the same time. Referring to the A B C system, he said the weight of chemicals used in the treatment of 1,000,000 gallons of ordinary sewage was:

	Tons.	Cwts.	Qrs.	Lbs.
Alum	·1	17	0	0
Clay	2	14	1	0
Blood	0	0	4	14
Charcoal	1	4	0	0
Lime	4	1	19	0

Mr. Angell said he wished to make some rather general remarks. Although the question of the treatment of sewage was, to the Members, somewhat a worn-out subject, at the same time it had a practical interest, but if they were to talk to any extent it would be impossible, at present, to state anything which was not already known. The Society of Arts had recently called a conference, which was supposed to embody the wisdom of the country; they had also issued a report and recommendations upon the subject, but that report contained nothing which had not been discussed over and over again in this Association. They told them that sewage must be got rid of at any cost, that privies should be

discontinued, that no one system could be adopted for universal use. No doubt about all this; in fact, all that the report contained was simply an embodiment of what had been said over and over again in that and like associations. He thought that the Legislature would do well to assist towns in information as to how to avoid polluting rivers instead of prosecuting them for so doing. He had just been favoured by the Secretary of the State Board of Health of Massachusetts with their seventh annual report, and he wished to direct the attention of the meeting and of the country to the difference between the laws of England and America on this subject; it was an obligation of the State Boards in America to advise as to the best way of protecting rivers, estuaries, &c., from pollution. In this country legislation had compelled them to turn the sewage into rivers; but no sooner had that been done than the Conservancy and Pollution Acts imposed penalties for so doing, and there had been no attempt on the part of the Government to show them how they were to comply with the new law. In this respect the spirit of sanitary legislation in America was in advance of that of England. He was interested in Mr. Morant's paper, but he (Mr. Angell) was of opinion that chemical science held out no hope for effectual sewage treatment excepting at an enormous cost. They had seen in Manchester the pail system in operation, and as carried out there, in the town yard, he had never witnessed anything more disgusting; indeed, although he was not over-fastidious in these matters, the spectacle he had seen positively sickened him. Adjoining the town yard there was a most magnificent abattoir, where cattle were killed and dressed by the most ingenious mechanical contrivances, and afterwards distributed for food throughout the surrounding country; immediately adjoining the abattoir the dust refuse and excreta of the city was deposited, mixed up and manipulated; the sight and the smell was most disgusting, and he wondered how men could be found for the work. Remembering Professor Tyndall's lectures on floating dust particles and the germ theory of disease, he was led to the consideration of the effect upon the health of the locality and of those who partook, at a distance, of the meat from the abattoir; he hoped Manchester would lose no time in altering the present disgusting arrangement. With regard to Mr. Buckman's paper on the sewage of Ipswich, he advised that sewage wherever practicable should be sent to sea.

Mr. Pritchard endorsed all that had fallen from Mr. Angell with reference to the Manchester system.

Mr. Lynde said they all knew that it was very important that deposition should take place rapidly and regularly in the tanks, and that this took place in the proportion with the velocity of the water; now he did not himself think that a rectangular tank was the proper one for sewage tanks; he was of opinion they should be deep and narrow at one end and shallow and wide at the other end, by which means they would get a better mixture, and the water would flow more evenly. He mentioned the matter now in the hope that he might have some experience on the subject.

Mr. Morant said the trough system of closet was being introduced in Leeds; it was most cleanly, and no nuisance could arise from it, as it was emptied every third day, and it could not be lifted or opened by the person using it.

Mr. Lynde said a very similar thing to this was introduced in 1843.

Mr. Morant said the pail system had been tried in Leeds, but it was so disgusting that it was now almost entirely abolished.

Mr. Grindle had been trying the Goux system, and he did not think there could be a more cleanly way of dealing with the matter; earth-closets would suffice for small villages containing ten or twenty cottages, but not for large towns.

Mr. Clarlie said, for the past nine months he had lived in a town that used the tub system, and anything more disgusting it would be impossible to imagine. The principal objection to water-closets was they very soon got out of order; the trough closet was a most simple thing, and the quantity of water was reduced to a minimum. It would be a good thing if school boards would take up these matters and teach people the duties of public and private sanitation; the duties of engineers would be comparatively easy. He advocated the water-carriage system wherever it could be carried out.

Mr. Lobley remarked that the discussion on Mr. Buckham's paper would be useful, inasmuch as it would disabuse the public mind of the prevailing opinion that the pail system was preferable to any other; and what was more, such men as Sir Henry Cole had spoken in favour of the dry system. Without defending the dry system he said there were 1200 pail closets in Hanley, and 6000 privies and only 250 water-closets; the farmers would fetch away the clear sewage, but if mixed with ashes they would have nothing whatever to do with it.

Mr. Cartwright said Dr. Buchanan and others had told them

recently that the pail system could be carried out without a nuisance, and this was a point which the Association felt compelled to give some notice to.

Mr. ANGELL said they knew by practice that this never had been done.

Mr. ALLEN recommended the single-closet system; if the pail system would collect everything, its advantages would be much greater.

Mr. LYNDE said he had had some public privies erected in Manchester on the sloping sides principle, and he found them a great acquisition.

Mr. BUCKHAM would like Mr. Grindle when he replied to give his experience as to the best mode of disposing of the sewage of reasonably sized towns.

The PRESIDENT thought one objection to the A B C process was the increase in the bulk of sewage. Mr. Morant had told them in his paper the number of tons of matter which were necessarily added to purify the sewage, that rendered it so bulky that the farmers did not care to take it. He thought more might be done in carrying out a separate system in many towns, though not in all. Mr. Morant had referred to the difficulties experienced in consequence of dye works and other manufactories, and he thought it only fair that the proprietors of these places should pay any extra expense to which the local authorities might be put. It had been shown by Franklin that nearly all the refuse from these establishments could be dealt with on the premises, and the Government should compel these manufactories either to do this or discharge only liquid into the sewers. With regard to Mr. Buckman's paper, he was equally sorry with others that he was thinking of adopting the pail system; rather than do that he would carry the sewage to the sea, for Ipswich was only 12 miles distant; and although the country was flat a small gradient would answer the purpose. Mr. Grindle recommended that water tanks be covered, but his experience was in opposition to it; the fact of the water being exposed to the air rendered it more pure. Referring to the Manchester abattoir and the refuse depôt being so close to each other, he accounted for it by the fact that the two matters would come within the jurisdiction of two different committees, probably that was the reason of the blunder.

Messrs. MORANT and BUCKHAM were each cordially thanked for their papers.

DISTRICT MEETINGS

OF THE

ASSOCIATION.

DISTRICT MEETING AT CHELTENHAM.

THE Seventh meeting of the District Committee for the Midlands was held at the Town Hall, Cheltenham, Oct. 21, 1875.

Present: Messrs. Edward Pritchard, Vice-President and Hon. Secretary for the Midland District (Warwick); C. Jones, Hon. Secretary (General), Ealing; D. J. Humphriss, Cheltenham; J. E. Palmer, Malvern; G. Cole, Hereford; J. Lobley, Hanley; and T. Cruse, Warminster.

Also the following visitors: Dr. Wright, M.O.H., Cheltenham; A. J. Ingram, Warwick; G. Winship, Malvern; G. W. Sadler, W. H. Astonan, H. D. Humphris, Cheltenham; Dr. Bond, M.O.H., Gloucester, and Captain Lyons.

The Committee met at the Town Hall at 12.30 noon. Mr. E. Pritchard, Vice-President, occupied the chair, and as Honorary Secretary read the minutes of the last meeting, held at Northampton, April 15. On the motion of Mr. G. Cole, seconded by Mr. J. Lobley, they were approved.

Mr. E. Pritchard was then re-appointed Hon. Secretary for this district.

The existing sub-committee were unanimously re-elected on the motion of Mr. G. Cole, seconded by Mr. J. E. Palmer.

Mr. D. J. Humphris then read a paper on the sanitary development of Cheltenham, with statistics.

The company then visited the reservoirs, where they were met by Mr. W. McLandsbrough, the engineer to the Waterworks Company, who conducted them over the works. The weather being unfavourable for proceeding to the Sewage Irrigation Farm, it was decided to hear Dr. Wright's paper on the geology of Cheltenham and the Cotswolds, in a building on the works.

After which the company visited one of the sewer outfalls, where the sewage is allowed to settle in tanks, the solid matter being afterwards mixed with ashes and sold to the neighbouring farmers at the rate of 2*s.* per cube yard.

Votes of thanks were passed to Mr. D. J. Humphris and

Dr. Wright, F.G.S., for their valuable papers, and to Mr. E. Pritchard, for his services as Hon. Secretary for the Midlands.

After Mr. D. J. Humphris's paper was read in the morning, a short discussion took place in reference to fever hospitals, in which Messrs. Cole, Lobley, Palmer, and Drs. Wright and Bond took part.

In the evening the company dined at the Queen's Hotel, Dr. Wright occupying the chair.

ON THE SANITARY DEVELOPMENT OF CHELTENHAM.

BY MR. D. J. HUMPHRIS, TOWN SURVEYOR.

IN endeavouring to conform to the programme of this day's proceedings, which has been forwarded to the members of the Association by our esteemed and pains-taking Hon. Secretary, and in offering a few remarks upon the "Sanitary Development of Cheltenham," I feel that the length of time at disposal renders it necessary that I should compress them as much as possible, and therefore I shall not attempt to enter into any minute details.

During the past few months, active steps have been taken to effect the incorporation of the Borough of Cheltenham, but heretofore its municipal and sanitary matters have been subject to the direction of a board of thirty Commissioners, acting under the authority of the "Cheltenham Improvement Act of 1852," whereby one-third of the number retire yearly in November, when a fresh election takes place to fill up the vacancies. Prior to the obtaining of this Act the town had been governed by Commissioners deriving their authority from preceding private Acts. Several important public Acts of Parliament having, however, passed about 1847 and 1848, an impetus was given to sanitary and municipal legislation; and although the Public Health Act of 1848, and other Acts, were not adopted in their integrity, yet in our new local Act, the most important provisions and clauses thereof were incorporated, and thus advantage was taken of the legislative enactments which had throughout the country given such increased facilities for carrying into effect sanitary improvements; and although many difficulties have had to be encountered from time to time, I trust it will appear evident that the governing body of Cheltenham have not been inactive or obstructive, nor insensible to the important trust reposed in them in regard especially to the sanitary condition of their district.

Few towns perhaps possess greater natural advantages than Cheltenham. Its general altitude is from 150 feet to 250 feet

above the sea level, and its surface drainage is into three stream, (the Chelt, the Wyman brook, and the Hatherly brook) which are tributaries of the Severn, and in connection with these great facilities are given for drainage operations. A considerable portion of the town is built upon the blue lias clay, but the greater number of the houses are built upon a deep bed of sand or gravel overlying the blue clay. Co-extensive with this sand bed, a good supply of water may be obtained, and which forms, or has formed, the usual supply for a large portion of the town, wells having to be sunk to depths varying from 10 feet to 30 feet from the surface.

The high lands of the Cotswolds on the east of Cheltenham, comprising the Oolitic district, doubtless form the subterranean supply to the sand bed whereon the town is built, and the streams or brooks before referred to derive their supply from the same source.

Many of the small feeders, however, of these streams have been intercepted near where they rise, and have been turned to account by the Water Company, who, under the authority of several Acts of Parliament, are empowered to supply this and certain adjacent parishes with water, and to levy taxes for the same. As, however, these works are to be inspected and more fully described, Mr. McLandsbrough, the Company's Engineer, having kindly given permission and afforded facilities for the purpose, I shall not do more than speak in the highest terms of the quality of the water, which has sufficient head in the reservoir to flow by gravitation to an altitude considerably above the highest parts of the Town.

Previously to obtaining the Act of 1852, the drainage of the town was most unsatisfactory. The houses erected on the sand bed, where somewhat distant from a stream, had cesspools on the premises, into which all offensive matter was conducted; others were drained direct into the streams, and patent sewers were constructed for limited districts. There was also one large sewer formed along the High street, with branches from the side streets, and this was the work of a Company empowered to carry it out by a special Act of Parliament. The sewage from these sources was discharged into the streams referred to, and I need hardly attempt to describe their polluted condition prior to our local Act being obtained.

One of the primary objects of this Act was to free the streams from sewage pollution, and to effect this, powers were obtained to construct three main intercepting sewers, following generally the

course of the three streams, and thereby cutting off all branch sewers and drains from the streams, to secure as far as practicable their purity and their freedom from offensive matter. These main sewers were led to tanks, one situate at Hatherley and the other at Arle, near the lower extremity of the parish. These tanks are both in duplicate, each of those at Hatherley being about 50 feet by 13 feet, and each of those at Arle about 130 feet by 14 feet.

No time was lost when once the authority for the construction of these works was obtained, and they were carried out by the late surveyor, Mr. Dangerfield, who had designed the whole of them, the cost being about 11,000*l.*, which was raised by loan, to be repaid with interest in thirty years.

Another important object provided for by the Act was to carry out a general system of branch sewers throughout the town. On the three principal private estates sewers had been constructed by the proprietors thereof, having, however, no other main outlets than the streams. With these estates no great interference took place in respect of their branch sewers system, but for the remainder of the town a general and comprehensive system of branch sewers was carried out under the surveyor; the Commissioners also undertaking to purchase the whole of the works of the Sewers Company, and adopting them as part of the general design.

The length of the sewers thus formed or acquired, with further additions subsequently made up to the close of the year 1873, is as follows:

Brick Sewers	24 miles,	1586 yards.
Pipe „	8 „	1583 „

and the cost has been 23,000*l.*, raised on loan in the manner aforesaid, in addition to the cost of subsequent extensions made from the current yearly rates.

The drainage of all houses within the specified distance from sewers has of course been made compulsory, and thus cesspools have been abolished, and the streams purified.

The main sewers have legalized outlets into the brooks adjacent to which the tanks are erected. The tanks are simple subsiding and filtering ones, and for many years the lime process was to a limited extent carried out. The result, however, was not satisfactory, and loud complaints as to the polluted state of the streams below the outfall were made by the owners and occupiers of land

and property adjacent thereto, and legal proceedings were threatened. Perchloride of iron was also subsequently used for a considerable period, and a trial was given too to the system known as Bird's process. All of these systems, however, though involving a large and constant expenditure, resulted in failure, and after much thought and deliberation it was decided to adopt the principle of irrigation. The situation is eminently favourable to this system, and having succeeded in obtaining by purchase a tract of land at a distance below the tanks, I have been enabled to convey the fluid sewage thereto by simple gravitation and to utilize it on the land.

At the tanks, however, the solid portions of the sewage are removed, chain pumps being used for that purpose; and at Arle the stream of sewage itself is utilized for working a turbine, which keeps the pump in action most successfully, and at a great saving of labour in the work of emptying the tanks. The solid portion of the sewage is mixed with ashes, and sold to farmers at the rate of 2*s.* per cubic yard.

Both the outfall sewers are so laid as to meet at nearly the same spot, on the farm belonging to the Board. The length of the one from the Hatherley tank is 1 mile 4 furlongs 163 yards, and from the Cheltenham tank 2 miles 7 furlongs 85 yards. They are laid with an average rate of fall of about 8 feet in a mile, and are constructed with great care, so as to secure a regular and gradual fall, and they contour around the gentle slopes of the ground, having in their course outlets formed at suitable points, so as to enable intervening lands belonging to other proprietors to be irrigated when required, and for which a small rate of charge is made. And thus, although the quantity of land at present belonging to the Board is necessarily somewhat limited, an additional area of some 200 acres or so is brought into use.

At present merely a very small portion of the land of the Board, only about six acres, has been broken up and sown with Italian rye grass. The remainder is permanent pasture, and with care and attention, and a good deal having been done in the way of drainage, the sewage is both utilized and purified, and the state of the brooks, which before was most offensive, has been rendered very satisfactory, so that since the adoption of this system the Board has had no complaint in regard to the condition of these streams.

The quantity of land purchased by the Board for sewage utilization is 131 acres, and the cost thereof, together with the

outfall sewers, was 18,000*l.*, raised in the same manner as in the case of the public works before referred to.

Thus in sewerage works alone Cheltenham has expended 52,000*l.* A large portion of the amount has, however, been already paid off; and the expenditure, looking at the sanitary condition of the town, has been a most judicious one.

The death rate of Cheltenham is low, being, according to Dr. Wright's report for the year 1874, only 17·2 per 1000.

The branch sewers rate is 4*d.* in the pound, paid as a separate rate by those parties who are chargeable to it.

The rate for repayment of loans and interest for main sewers and tanks, and for the sewage utilization, is spread over the whole borough, and is merged in the general borough rate; but both together, taking into account the proceeds arising from tank-manure, and from the receipts from the farm, entail an annual expense to the town of less than 1½*d.* in the pound, while in a sanitary point of view the result has been most satisfactory.

Of course a great deal of other sanitary work has been done in the town, in the repair of private streets, courts, &c., some eighty of which, to an extent of upwards of 8 miles in length, have not only been repaired, but subsequently taken to by the Board as public henceforth.

Intra-mural interments having been gradually abandoned, a public cemetery, 18 acres in extent, was laid out about fifteen years ago, at a cost 11,000*l.* to the Board.

With a view to the more efficient working of the highways, scavengering, and other departments, a Central Depôt was designed and carried out two or three years ago, at a cost of 7000*l.*, there being a siding and direct railway communication in connection therewith from the Great Western Railway. This is found to be an immense benefit in the control and regulation of the public works.

MEETING OF THE HOME AND MIDLAND DISTRICTS AT OXFORD.

The Home and Midland District Committees of the Association held a meeting at Oxford on Friday, February 18, 1876; the proceedings commenced at 11.30 in the Council Chamber. The chair was occupied by Mr. Lewis Angell, London (Past President); the other Engineers present being Messrs. Pritchard, Warwick (Vice-President and Hon. Sec. for Midland District); Ellice-Clark, Derby (Hon. Sec., Home District); Morant, Leeds; Parry, Reading; White, Oxford; Lobley, Hanley; Davidson, Leamington; Stayton, Chelsea; Batten, Aston Manor, Birmingham; Fereday, Wednesbury; Allen, Stratford-on-Avon; Comber, Kidderminster; Cole, Hereford; Monson, Acton; Nicholson, Axbridge; and Smith, Milverton. There were also present the Dean of Christ Church, Dr. Acland, Mr. C. Neate, Captains Douglas Galton, Sturt, and Ferrier, R.E.; Justices W. Ward, Galpin, Pike, G. Ward, Calcutt, and Towle; Aldermen Spiers, Dore, and Carr; Messrs. Winkfield (Medical Officer of Health), Goold, Hussey, Downing, Burstal (Windsor), Eldridge, Smith, Horlock, Cobbold, MacBrair, Acland, jun., Poulton (Jesus College), Shirley, Dover, Dickinson, Acock, Boon, Hobdell, and Williams.

The following papers were read.

OXFORD MAIN DRAINAGE.

By Mr. W. H. WHITE, Assoc. Inst. C.E., City Surveyor.

Before proceeding to describe the Main Drainage Works themselves, it may not be out of place to give a few statistics which bear more or less directly upon the subject, and to sketch very briefly the history of the drainage question here down to the commencement of the works.

The population of the Local Board District, including the University, is somewhere about 35,000, and as those figures show an increase of over 7000 in fifteen years, I have thought it advisable to reckon upon an ultimate population of 45,000. The rateable value is about 137,000*l.* The area of the city and suburbs is about 2000 acres. The length of streets and roads repairable by the Board is 28½ miles, and there are also in the district 5 miles of road maintained by Highway Boards, Turnpike Trusts, and private individuals.

The town is mostly built upon a bed of gravel lying on the Oxford clay; some parts, however, stand upon the clay itself, and others on made-up ground, which is occasionally 8 or 10 feet thick. Geographically, the place is situated principally on a peninsula bounded by the rivers Thames or Isis, and Cherwell; but a large suburb has recently grown up on the further or eastern side of the last named; and within the last few months the jurisdiction of the Local Board has been extended to an outlying district on the Berkshire side of the Thames, containing the City Water Works. As so much of Oxford extends along the low ground skirting the rivers, some of it below flood level, as proved by recent experience, and at all times charged with water almost to the surface—the town, moreover, being intersected by numerous navigable and other streams,—it is evident that a scheme which shall bring to one common outfall the sewage of the district must involve a large outlay. It is not therefore surprising that the Improvement Commissioners previous to, and the Local Board since, 1864, though convinced of the necessity of drainage, hesitated

to embark upon such a work, though they had no lack of engineering advice, for between 1851 and 1871 the services of the late Sir William Cubitt, Mr. Bateman, Colonel Ewart, R.E., Mr. (now Sir) J. W. Bazalgette, and Messrs. Galpin and Clark, my predecessors in office, were put in requisition. Although the various schemes prepared by these gentlemen necessarily differed considerably, I was able to collect from their reports much valuable information, having to undertake the work when quite strange to the city and neighbourhood, and heavily engaged with other Board work. Even since the completion and adoption of the present scheme and its sanction by the Local Government Board (viz. in 1872), residential objections having been raised to the proposed site of pumping station, and to a second site I suggested as a substitute, *another* engineer (Mr. Bailey Denton) was called in to report upon that point, and in doing so took occasion to recommend certain land for irrigation (the principle having been before determined upon though no land absolutely selected). Mr. Denton's recommendations of this land and a third site for pumping station were adopted and incorporated in the scheme.

Much opposition has, of course, been offered by owners and occupiers outside the district, affected (or supposed to be) by the proposed works, and one or two battles having been fought at Local Government Board inquiries, but these obstructions have been gradually removed, fortunately without any legal proceedings.

The water-closet system has long been in use in Oxford, and in more recent times much extended, therefore in preparing the present scheme I found most of the city had sewers discharging into the various streams. Many sewers were good, others quite the reverse, and not a few were but the remnants of old ditches built up in a primitive fashion with dry rubble work, all unventilated, and only two provided with flushing apparatus. In the principal streets most houses were connected with the sewers, but in other parts the connections were fewer, and in many suburban roads the only resource was the cesspool, or a dry system. The Board having adopted the separate system, it became necessary to duplicate the old service of drains, and where none or only bad ones existed, to lay down both sewers and surface drains. For the most part, the old sewers have been utilized for surface drainage, their house connections being transferred to the new system, but in a few cases this mode has been reversed by incorporating the existing sewers with the new scheme.

The total length of sewers and surface drains in the scheme is 32¾ miles, viz.: 7¾ miles of brick sewers, varying in size from 4 feet 6 inches by 3 feet to 2 feet by 1 foot 4 inches, and 25 miles of pipe sewers and drains, with 510 manhole and lamphole openings. The works were commenced in June, 1873, and 5¼ miles of brick sewers (including about two-thirds of outfall sewer), and 17 miles of pipe-drains, have now been completed, leaving a balance of 2½ miles of brick and 8 miles of pipe to be done. With one or two trifling exceptions, the whole of the pipe, and also the brick sewers, smaller than 3 feet by 2 feet, are laid in straight lines, with manholes or lampholes at every change of direction or gradient, and particularly manholes, at every junction of two or more lines, the curves necessary to unite them being (in the case of pipe sewers) formed in the brick bottoms of these manholes, with a few inches fall from the smaller into the larger line. Manholes on brick sewers have not these curves, but the lateral lines have a free fall into the main, turned slightly in the direction of the flow. By these arrangements a sight can be taken through, from one opening to another. Bell-mouths are built at junctions of large brick sewers, upon which too the straight line principle is adhered to where fairly practicable, and resting places 6 feet high by 4 feet long, each with ventilating shaft, are introduced at intervals between the manholes. Ventilation is obtained by open gratings at surface of ground, except at the heads of a few sewers in very confined spaces, where a pipe is laid to the nearest chimney or other high point. The manhole covers, which are circular on plan, were, in the first instance, of the type so much used, viz. of cast iron, with radiating divisions, the spaces within them filled with wood blocks. The grating was independent of the cover, and fixed over a small brick chamber communicating with the manhole shaft, but having found in working that there were several practical objections to this form, I have since substituted a cover, having a circular grating in its centre, underneath which is suspended a circular sheet-iron box to catch road detritus, &c. I have also substituted for the ordinary cast hand and foot irons, light wrought-iron ladders, which are about equal in cost, but much safer and more convenient. The manhole shafts are square, and of 9-inch brickwork. They are in wet ground built all stretchers, thus giving a collar joint all round; but where there is no subsoil water, they are in old English bond. The lampholes are but smaller editions of the above. Where the new sewers

are in use, the above system of ventilation works well on the whole but on some of the outlying roads, where the house connections are few and far between, and consequently the flow very small, complaints have been made of offensive smells. To remedy this I have had recourse to frequent flushing, which proves effectual.

I should at this stage explain that having been able to secure several temporary outlets, the house drains of more than a third of the city can be connected with the new sewers, as soon as laid, and it will be only the work of a few days to turn this sewage into its permanent channel when the proper time arrives, some of these outlets still remaining available as overflows, should they ever be required in that capacity. The principal of these outlets is near Magdalen Bridge, where the sewage passes off by an arrangement which is practically an inverted syphon.

A manhole or lamphole is placed at the head of every line of sewer, to serve also as a flushing shaft. The water is laid on by a $1\frac{1}{2}$-inch pipe and screw-down tap from the nearest water main. The sewer being shut off by a flap at bottom of shaft, water is admitted, allowed to rise several feet, and then, by opening the bottom flap, is discharged into the sewer through a 9-inch pipe in three or four seconds. At intermediate manholes, flushing stops are provided, which slip into grooves in the brickwork, and pond up the sewage from 18 inches to 3 feet, according to circumstances, giving an excellent scour when released by raising the stop. The temporary outlet near Magdalen Bridge is flushed on this principle by a door working within a wooden grooved frame, built in wall of manhole, the door being raised from above by chains. These arrangements have been found to keep the sewers quite clean and free from deposit; but with a view of obtaining still greater flushing power on those main sewers where the fall is very slight, or the frictional resistance considerable from numerous curves, varying in radius from 9 feet to 20 feet, wooden penstocks are provided at suitable intervals, to be raised or lowered from above by a rack and pinion apparatus. These penstocks are 5 feet 6 inches high, and are so fixed that in the event of neglect in raising them at the proper time, the sewage would overflow and no mischief ensue. Another use they could be turned to is, that laying the sewers comparatively dry section by section for a few hours at a time, to facilitate inspection. The brickwork of all sewers is in Portland cement, gauged 1 cement to 1 sand, but the upper part of manhole shafts, where subsoil water is not

encountered, are in lias mortar. The concrete is composed of one part Portland cement to six parts of gravel and sand, which are found in abundance and excellent quality on most sections of the work. Concrete is largely used, the trenches being got out square for brick sewers, and a concrete backing formed and set before putting in the rings. Lias concrete of the like proportions is employed for piers over arch of sewer to sustain houses, &c., where necessary, as an alternative to leaving timber in.

The outfall sewer, 2 miles 176 yards in length, has a total fall of 4·84 feet, equal to 1 in 2290, or 2·31 feet per mile. It is 4 feet by 2 feet 8 inches, and 4 feet 6 inches by 3 feet egg-shaped, except under the two branches of the river Cherwell below Magdalen Bridge, there consisting of cast-iron flanged tubes of a peculiar section, 1 foot 11 inches high by 3 feet 9 inches wide, with straight sides and flat segmental top and bottom. I found this the cheapest form, combining the requisite capacity with a limited headway, which object had to be attained in order to obviate the necessity of inverted syphons, or the alternative of 2 miles of sewer at a lower level, and other consequences, the one specified being a serious matter, as will hereinafter appear. These tubes (which were laid within dams) were cast in 6 feet lengths, under the centre of the length of each a brick pier was built, truly finished on top to the cross sectional shape, and the whole accurately levelled in; the tubes were then lowered upon them and partly bolted up. The joints between the flanges were made with a composition of two parts Portland cement to one part iron borings, and while this was yet soft, the bolts were tightened a little. A few hours after the completion of this jointing, water was admitted within the dam, and an internal examination showed the work to be watertight. The water having been again withdrawn, concrete was filled in round the tubes, 18 inches thick underneath and a foot at sides and top. For the ventilation of the high bonnet-shaped arch, necessarily formed over each end, 6-inch pipes are carried through the crown, and back by an ascending gradient to the manholes a few yards away.

Next in importance to the outfall, and exceeding it in difficulty in some respects, is what I distinguish as the western sewer, which commences in Christchurch meadow by a junction with the outfall, and extends westward to Osney, beyond the Great Western Railway station. Its sizes are 3 feet 6 inches by 2 feet 4 inches, 3 feet 3 inches by 2 feet 2 inches, 2 feet 3 inches by 1 foot 6 inches,

2 feet by 1 foot 4 inches, &c., and gradients 1 in 1760, 1 in 824, and 1 in 677. It traverses by a very sinuous course (but the shortest that could be found) a neighbourhood abounding in narrow streets and sharp corners; thus the usual troubles with existing drains, gas and water mains, &c., are here present in great force. Besides these minor impediments, the sewer passes twice under an old culvert known as Trill Mill Stream, which is both a sewer and an underground arm of the river; and under three branches of the Isis, one being the main navigation, which is crossed by an inverted syphon; also underneath the Great Western Railway, a few yards from the station; and (to avoid another river-crossing) under an old Saxon tower, 87 feet high from crown of sewer, being the remains of Oxford Castle. The heading under this cuts through a narrow pass between the river and a large underground tank, whence the county prisoners raise the water by a capstan in the tower above, which works a set of pumps. Notwithstanding the presence of a body of water within five or six feet on either side of heading and at a higher level, the work has been comparatively dry save for a little leakage from the river through the foundation of tower and boundary wall. The iron pipe conveying the water from river to tank crosses the heading at level of crown of sewer, in which a piece of ⅜-inch boiler plate will be inserted under the pipe to guard against fracture and consequent flooding. The whole of the timbering will be built in, and the space over sewer filled up solid with brickwork in cement, so far as it is under buildings. The tunnelling, 202 feet in length, has been driven entirely from the southern end, and as it was impossible (without a special erection for a theodolite on summit of tower) to range the line over it to find end of heading on north side, I was obliged to discover the spot by a series of survey lines crossing river, carefully measured, and the angles taken with the theodolite. The result from measurement on plotted diagram (drawing No. 3) and from calculation, agreed within 6 inches; the former was taken as correct, and shaft length sunk in street, centre line of which hit that of heading as nearly as possible. The crossing under Great Western Railway will also be tunnelled, the timber being built in, and heading bricked up solid as above. The crossing under the two branches of the river at Pacey's Bridge is by cast-iron tubes with egg-shaped invert and sides and segmental top; and that at Osney, of circular pipes 15 inches diameter. These will all be laid within dams, jointed

and concreted, as described for the Cherwell crossings. The sewer is carried under Trill Mill Stream of the ordinary form in brickwork and concrete springing high, but for the arch are substituted cast-iron segmental plates ⅞ inch thick, stiffened longitudinally and transversely by ribs 2¼ inch deep. The side flanges abut on York stone skewbacks, and the whole is surrounded with concrete, upon which the brickwork of the old culvert is rebuilt. I have designed an arrangement of sluices, &c., by which this stream can be laid dry to within a few inches of its invert, the water running off into the sewer below.

The north-western sewer, which is principally 3 feet by 2 feet, with gradients 1 in 1000, 1 in 600, 1 in 500, 1 in 109, is carried on the skew under the canal by the same form of construction as last described. It is hoped that for this crossing, or at all events the greater part of it, a dam can be dispensed with, as the canal will probably be laid dry for a week at next Whitsuntide for examination and repair, thus giving the contractor an opportunity of pushing the work across in a very short time. The other principal sewers within the city have no specially interesting features such as those just described, though plenty of trouble with subsoil water and innumerable crossings under minor streams and old drains, breaking of gas and water mains, &c. The greatest depth on the work is in the case of the eastern or St. Clement's sewer (22 feet), which is caused by its having to receive the drainage of a number of streets falling about 15 feet away from its line towards the river Cherwell, alongside which the sewage could not be collected without considerable additional cost for embankments, &c.

To the sewer which joins the newly incorporated district of Hincksey with the outfall sewer, belongs the distinction of having the widest and deepest river crossing, being carried under the river Thames below its confluence with the Cherwell, by an inverted syphon, laid some distance below the present bed of river, so as not to interfere with any scheme projected with a view of lowering the water level in river and soil, and of carrying away flood waters. (A commission formed for this object has been in existence about five years, and some such plan will doubtless soon be carried out. I will only remark that could the water level have been so lowered before the sewerage works were taken in hand, there would have been a large saving in pumping and construction on those works.) The Hincksey sewer is 2 feet by 1 foot 4 inches, with a gradient of 1 in

922. In designing the two syphon river crossings I have carefully kept in view their liability to accumulation of deposit, and believe this is tolerably well guarded against. Each consists of two vertical shafts, with manhole covers, ladders, &c., complete, joined at bottom by a straight line of iron pipes laid with a good fall, the shaft at lower end having a sump or catchpit 1 foot below pipes to arrest sediment, and also to facilitate the pumping out of the syphon when required. To assist in the latter purpose, sluices are provided at either end to cut off the sewer for the time, and that at upper end also enables a good flush to be given with 3 feet head of sewage. The pipes are, as in the other crossings, surrounded by concrete.

The pipe sewers are 18 inches, 15 inches, 12 inches, and 9 inches in diameter, thickness being specified to be at least one-twelfth of the bore. Their gradients are mostly between 1 in 400 and 1 in 100, a few being steeper, the quickest 1 in 11; some of the larger ones, however, range from 1 in 400 to 1 in 677, and two lines of 18-inch and 15-inch pipes are laid at an inclination of 1 in 800. As far as it is fairly practicable, the principle of quickening the fall of each sewer as its size diminishes and the summit is approached, has been carried out. The pipes are of Lambeth make, jointed in Portland cement, and in many instances a band of puddle has been added round each joint. In the presence, however, of strong springs, I found it impossible, even by the greatest care with the above method, to entirely exclude the subsoil water, so was led to use Stanford's patent joint in such wet places (being I believe the first to do so), and found it answer the purpose extremely well, some pipe sewers under a considerable head of water being absolutely watertight, and where any leakage does occur it is insignificant in amount. As all the members present may not be familiar with this invention, I will briefly state that it consists of a composition cast very accurately round the spigot end and within the socket, forming in fact a turned and bored joint, which is easily applied by the aid of a little grease, no cement or other jointing material being required, and the trench can be at once filled up, the latter an important gain in itself. The spigot being cast slightly convex, and the socket concave in section, it follows that some settlement or other movement may occur without destroying the contact. Care is of course required to ensure the absence of grit or other foreign matter in the joint at the time of insertion, and for this purpose it is I think advisable

to keep the water pumped down while laying the pipes. Where the deep main sewers also serve as street sewers (in order to reduce the openings into them, and consequently the risk of leakage to a minimum), I have provided for the house connections, at about every forty feet, a line of pipes leading up into a square brick chamber, covered with a York stone. In each face of this chamber, a pipe, temporarily closed by a stoneware stopper luted in with puddle, is built so that when brought into use the drainage of several houses will converge to each chamber, and pass thence by the vertical pipes and bend at bottom into the sewer. The pipes are surrounded by concrete to carry weight of chamber, &c. On the street sewers proper, the depths of which are of course regulated by more *local* requirements, junction pipes or side pipes in brick sewers (as the case may be) are provided in the usual way, with stoppers as before. A book is kept, in which the position of each is recorded. In setting out gradients I have adhered entirely to the sight-rail and boning rod method, the former painted black and white and fixed even feet above invert. Where progress is slow, the uprights for the rails are bedded in concrete, but even then they are found to sink, and require very frequent checking. In many places, where the ground was bad, they have gone down several inches in a day, and it was necessary to check them twice or more per day, in order to preserve anything like the true gradient. The bench marks, where near the lines of sewer, have been effected in a few instances, and altogether a rigid system of checking has had to be maintained.

The great feature in these works is the large volume of subsoil water to be kept down during their construction, and prevented from entering the sewers when completed. When it is stated that 8 miles of sewer are below the ordinary *summer* water level of the valley, the greatest head being 10 feet above invert, with about 4 feet more put on in time of *flood* (which increase of 4 feet also brings an extra mile or two under pressure), the necessity for strong construction will be apparent. But this is not all,—for several miles of sewers in the high ground pass alternately through ridges of the Oxford clay and basins of gravel formed in its undulations, and full of water. In a few instances these springs have been permanently tapped and let down to the valley level, but the majority have risen to their former height, putting the work under pressure.

The pumping has been very heavy, employing numerous port-

able engines and pumps, Gwynne's and Woodford's centrifugal and Murray's chain pumps being used, besides hand pumps. Some three or four months back I calculated that 5,000,000 gallons were being lifted daily. The effect of all this has been to temporarily drain most of the wells, and in order to partially remedy the inconvenience thus caused the Board has erected standpipes here and there for public use. The sumps are sunk 6 or 8 feet below invert level, and the water conducted to them by stoneware pipes laid beneath the sewer. In working both ways from a sump, the pipes have of course at the downhill face to be laid falling the contrary way to the sewer; this is effected by starting them 2 or 3 feet lower, and using a movable slide on the forward sight-rail in each bay, the height of crosspiece on boning-rod for the pipes being reduced by the thickness of slide as each bay is completed. The largest pipes used for this purpose have been 12 inches. On the Outfall, Western, North-western, Hincksey, and part of North-eastern sewers, upon which the hydrostatic pressure is greatest, I have had recourse to cement rendering to exclude subsoil water, two complete rings, ½ inch thick, being employed on the outfall, and one on each of the other sewers named. The cement for this is gauged two cement to one of washed sand, and laid on by plasterers in three coats, the setting being of neat cement. In fair average weather, twelve to twenty-four hours sufficed for this rendering to set hard enough to allow the bricklayers to resume work, and in some special instances it has been gone on with in six or eight hours, great care being used. Perhaps the best illustration I can give is the following quotation from specification for outfall sewer:—"Proper moulds to be fixed, and concrete placed in position, well rammed and allowed to set before moulds are removed. Concrete to be rendered ½ inch thick, finishing well over top of concrete. When concrete has set hard, put in outer ring of brickwork up to springing, and render as before. Rendering having set hard, put in inner ring to springing. Build inner ring of arch. Render same, taking care to unite with rendering between rings below springing line, and allow to set hard. Build outer ring of arch, and well wash in with cement between such outer ring, and the rendering on concrete from springing to top of concrete. Render outside of arch, uniting carefully with rendering on concrete." I have been enabled by the repeated floods which have so much hindered the works, to test the efficacy of the above construction, the result proving very satisfactory, and I have

reason to believe that the leakage in these sewers will be almost infinitesimal, as up to this time all I have detected is a slight sweating here and there, with an occasional trickle through a pipe connection.

The trenches have been generally in gravel, which stands well, but in some cases where the clay below has been dipped into, much trouble has been experienced from side water, and from the swelling of the clay, causing such heavy lateral pressure as to push over the green work, which had accordingly to be strutted ring by ring. The worst cutting of all was one about 18 feet deep, at Iffley, which went through 12 or 13 feet of peaty soil and running sand with occasional boulders of the formation known as calcareous grit, the bottom being in clay.

The weight was here so excessive that many of the settings of timber, 14 feet in length, required five horizontal besides several raking struts, and double walings were put in, but even with these precautions the walings bent inwards like a bow between the struts, the ends of which were frequently squeezed an inch into the walings, and a few bent and snapped. Occasionally the fibres in a waling would partially give way with an ominous report, which caused some uneasiness below, but fortunately there was no mishap. A crack, however, showed in the hill side nearly 100 feet from cutting, and followed it in a line nearly parallel for 200 or 300 yards, passing through two dwelling houses and causing settlements therein, one being of considerable extent. I had a great deal of timber left in, and in the worst part further strengthened the sewer arch by filling up the haunches with concrete to a height of 6 inches over crown. The bottom of trenches has generally been solid, but now and then in crossing old filled-up beds of streams, the excavation had to be carried deeper and filled with concrete to the proper level. Only once has piling been necessary under sewer, that being a length of 50 feet through quicksand; but a very troublesome work of this nature occurred in getting in the bottom of straining well at end of outfall sewer. Within 30 feet of it a boring had shown clay at 7 feet from surface, but here the excavation went down foot by foot without finding it, till it became evident we had happened on a fault or pothole. With much difficulty the ground was got out about 16 feet deep, and into a boiling quicksand, in which the quantity of water was so great as to keep blowing up the sand in miniature fountains, which shifted from place to place. I then determined to pile down

to the clay, and accordingly piles, 6 inches square and 10 feet long were driven over the area, connected by sills of the like section. A special sump having been sunk, I attempted to force the water into it round the outside of the piled space, by filling in the bays between sills with concrete gauged 4 to 1 and allowed to partly set before put in position, but soon found that unless frequent channels were left through the concrete it would all be washed into the sump. This being done, two courses of 3-inch planking were spiked down on sills, and on this the work was carried up without difficulty. Cement rendering was here applied as on the sewers. In excavating for the outfall and western sewers, a continuous bed of a kind of gravel conglomerate about a foot thick was found, which was as hard as cement concrete, and had to be broken by great labour with hammers and wedges. I presume this had been cemented by the water flowing off the beds of oolitic limestone near into the gravel, and some of it by the colour appears to have traces of iron in it.

I trust on a future occasion to have an opportunity, by the Association again visiting Oxford, of describing the pumping station, irrigation farm, &c. I will, therefore, in this paper only state very briefly a few leading points connected therewith. The site of the former has been already purchased, and the latter, which comprises 320 acres, varying from clay to a light, sandy soil, will very shortly become the property of the Board. The rising main will be 2 feet diameter and 2570 yards in length, with a rise of 56 feet. Estimated maximum quantity of sewage per day, two million gallons. Duplicate engines of 55-horse power will be required. A penstock is fixed at lower end of straining well, and an overflow provided into a concrete open culvert or canal, communicating with the river, by which channel canal boats can also be brought up close to the buildings. This channel can be emptied into the sewer when required. When the penstock is down, the great length of outfall and other sewers adjacent provides a reservoir capable of holding about a million gallons, the level of overflow being regulated at pleasure by stop boards.

Some of the drawings exhibited show a few of the complications met with in draining, on the separate system, an old city like Oxford, and my experience of them makes me hope that, should it ever be my lot to sewer another town, it may be one entirely innocent of drains or sewers, if such a place exist. I may mention, with regard to the old stone culvert shown on drawing No. 9,

that it was in the line of the city ditch, and ran for 400 or 500 yards under dwelling houses and their appurtenances. It was a sink of unimaginable filth, and the Board has done an excellent work in connecting the houses with the street sewer, and doing away entirely with the old drain in question.

My estimate made three years back for the whole of the works as they then stood, but not purchase and laying out of land, compensations, legal and other costs, was 85,000*l.*, which so far has proved near the mark. Including the above-named items (except the purchase of land), and certain additions since made by the Board, the cost will doubtless approximate to 100,000*l.* The works down to the pumping station have been let in five contracts (Nos. 2 and 3 being only about 2000*l.* and 3000*l.*; so arranged for special reasons), the whole amounting to about 76,000*l.*

In conclusion, I fear that in this paper, with the little new or original matter that I have been able to introduce, there must also be a great deal that to the majority of those present is almost wearisome by its familiarity; if, however, this be so, I still trust that I have, in endeavouring to describe the character of the works here, been enabled to bring before you some few features of interest in sewer construction, and I look to gather profitable information from your criticism thereon.

DESCRIPTION OF THE CITY WATERWORKS, OXFORD.

By R. DOWNING, Assoc. Inst. C.E., Resident Engineer.

The Oxford city Waterworks are the property of the Corporation and are under the management of a committee elected from the Town Council.

Up to the year 1855 the city was supplied direct from the river Thames, without any filtration whatever, by means of water wheels supplemented by steam power. Of course at this time the greater portion of the drinking water must have been obtained from wells. The main pipe was 10 inches diameter, and the highest lift was over a stand pipe discharging into a cistern erected in the Market Yard; the top of this pipe was about 35 feet above Carfax.

In 1855–56 the new pumping station at New Hincksey was constructed for the purpose of supplying the city from the Railway lake; a pair of 30 horse-power engines were erected by Messrs. Simpson and Co., of London, having double-acting pumps as patented by Mr. David Thompson, and known as the "Bucket and Plunger" pump.

A new main, 16 inches diameter, was also laid from the new station to Folly Bridge, where it was connected to the existing 10-inch main, and also to a new 7-inch main laid thence to Carfax.

At this time the consumption was about 450,000 gallons per day of thirteen hours, viz. 6 A.M. to 7 P.M., and one engine was sufficient for this purpose; but in course of time the demand had so increased (viz. to about 1,000,000 gallons per day of thirteen hours) that it had been found necessary to work both the engines simultaneously, and also to lay another main, 12 inches diameter, from Folly Bridge to Carfax (Carfax being a central point whence all the mains diverge): the city was thus placed in the unpleasant position of being liable to be without water in case of fire or for other purposes, in the event of any accident happening to the engines.

To obviate this state of things, it was decided in 1861–62 to erect another engine equal in power to the other two combined,

viz. 60 horse-power. This engine was erected by the Butterley Iron Company, the main pump in this case being double acting, but of the solid piston type, having suction and delivery valves at top and bottom respectively. Immediately on this engine being ready for work, the others were allowed to stop for the repairs which had now become somewhat urgent from the large amount of duty which they had performed, and which only their being of first-class workmanship had enabled them to accomplish.

We have now a little over 30 miles of mains, about 15 miles having been laid during the last eleven years—our smallest mains are 2 inches diameter, but it has now been decided to lay none smaller than 3 inches, except in very exceptional cases.

We are now pumping a little over 2,000,000 gallons, but this arises in a great measure from our being in a manner compelled to work night and day, owing to our not having a high-service reservoir; and not having any regular inspector, a large amount of waste necessarily prevails.

This state of things is now, however, in a fair way of being remedied, as we obtained, in the last Session of Parliament, power to construct a high-service reservoir, together with an 18-inch main from the works to supply the same, and also several other necessary powers for the proper and economical management of work of this description.

Top water line in the contemplated reservoir will be about 120 feet above Carfax, and about 143 feet above the level of engine floor.

According to Dr. Letheby's analysis the quality of the water is as follows, viz.:—

CONSTITUENTS PER IMPERIAL GALLON.

	Grains.
Actual or Saline Ammonia	0·001
Ammonia from Organic Matter	0·005
Nitrogen or Nitrates	0·126
Carbonate of Lime	10·54
Carbonate of Magnesia	0·36
Sulphate of Lime	3·13
Chloride of Sodium	1·22
Nitrate of Magnesia	0·74
Silica and Alumina	0·43
Organic Matter	0·60
Total	17·02

Degree of Hardness	13·2°
Ditto after boiling ½ hour	2·8°

Discussion being invited upon the papers, Mr. Towle was the first to rise, and, in his characteristic manner, proceeded to show that all that had been done was upon a wrong principle, when the Chairman reminded him that he was wandering from the purpose of the meeting, that being merely for discussion upon the engineering points raised by the papers, not the merits of the system of drainage itself. Mr. Towle then asked what could be done with the sewage at the irrigation farm in time of frost and snow, to which the Chairman replied that Mr. White had expressly stated in his paper that the subject of the farm would be treated at a future meeting; but Mr. Ellice-Clark added the ascertained fact that the normal temperature of sewage is about 52 degrees Fahrenheit, therefore there would be no fear of the result apprehended by Mr. Towle. That gentleman, however, persisting in speaking on irrelevant matters, was finally called to order by the Chairman and sat down.

Mr. Winkfield, Medical Officer, asked for the opinion of the meeting upon the method of ventilation adopted, remarking that although at first somewhat doubtful about it, he was now of opinion that the principle combined with the frequent flushing was unobjectionable, adding that he believed the new sewers had been unjustly credited with many foul smells arising from other quarters.

The Chairman spoke strongly in favour of open ventilation at the surface, as in Oxford, and quoted the recent extensive application of the system at Leeds, which Mr. Morant, the Leeds Borough Engineer, explained, stating that 13,000 of these openings had been made, and found quite free from objection.

Mr. Ellice-Clark (Derby) said that having been engaged for eighteen months in experimenting daily on the flow and chemical composition of gases in sewers, and the different kinds of ventilators, his experience had led him also to prefer the open principle to any other, which remarks seemed to accord with the general opinion of the meeting.

Capt. Galton asked to what extent the separate principle had been applied with regard to house drainage?

Mr. Lobley inquired whether it would have been applied to a scheme by which the sewage, &c., could have been got rid of by gravitation? also, if it was proposed to treat the surface water by any other works; or if not, was its character such as to render it fit for admission to the river?

Mr. White replied at length to these several queries, and to one

from Mr. Burstall as to the water supply per head, calculated upon in the scheme. Mr. Downing also explained that the present supply would be much reduced by measures for putting a stop to the waste of water.

The Chairman approved of the separate system, contrasted the spirited action of Oxford in carrying out such a great work of drainage, with the inaction of Cambridge in the like matter; referred to the difficulties to be overcome in the work now in hand, and consequent large outlay involved, and concluded by moving a vote of thanks to Mr. White for his paper.

Mr. Morant, in seconding the above, also strongly advocated the separate system, and stated that having already had an entire day to go through the plans and works, he was in a position to speak to their excellence.

THE RELATION OF MODERN ENGINEERING TO PUBLIC HEALTH AND LOCAL GOVERNMENT.

By DR. ACLAND, F.R.S.,

Regius Professor of Medicine in Oxford;

President of the Medical Council of the United Kingdom.

There is no chapter in human history more interesting and instructive than that which tells of the progress of the art and science of engineering. When that whole history is hereafter written, it is not rash to say that British engineers will stand out pre-eminent. Though Indian work may rival theirs in beauty, Italian in grace, Egyptian in solidity, Roman in municipal service, they will in the combination of their qualities be found to have been equalled by none. And yet, how short is the period in which British workmen have earned this fame. Some still living can remember when the lighthouse on the Eddystone was a novelty. I travelled, as a boy, on the first steam-worked passenger railway shortly after Huskisson's death. Many now living saw the first telegraph wire stretched along the Western line. Steam applied to the largest men-of-war is but a recent affair. Ironclads were begun only the other day. A full appreciation, by the masses, of sanitary engineering, even if it exist now, is not of five years' duration. Three years ago, a well-known speaker thought on a public occasion to gain a cheer by seeking to cast ridicule on those who prefer, like you, to prevent preventable disease, rather than only to cope with it unprevented. A like course would not be attempted now. Considering, then, the infancy of knowledge and of public opinion on this matter, it is not strange that the place of the sanitary engineer is not yet precisely defined.

In the Public Health Act of 1875, the summary of all health enactments, the name of engineer does not once occur in the 343 clauses. He is still the old "Surveyor" we all remember, the plodding, energetic man of highways and byways, whose Anglo-

Saxon vigour broke forth from the garb of corduroy, from the measuring-tape and links, into the transcendent skill of Macadam; and whose followers take rank with men of courage, and knowledge, and power, such as Brindley, Smeaton, Rennie, and Stephenson.

In considering the Consolidated Public Health Act, it is strange to see how the higher place of an Engineer is, by implication, conceded to him. Every urban authority may be "Surveyor of Highways," § 144; shall appoint "a fit and proper person to be Surveyor," § 189; and "the same person may be Surveyor and Inspector of Nuisances," § 192. But then the surveyor of the present day may be called to advise on anything, from the form and cost of an earthen syphon-trap, to the calculation for work to be done by engines, which are to supply half a million of persons with water, safe to be sipped in wine-glasses, and delivered in quantities adequate to cleanse the foulest and largest of factories; to be responsible for the construction of sanitary mechanisms, from a housemaid's sink to an "intermittent downward filtration" farm. If required to act also as Inspector of Nuisances, he is to have knowledge of what is dangerous to the public weal in respect of any and all nuisances; of all filth-producing agencies; of soundness and unsoundness of food; of occasions of epidemics and contagions. He is to be able to carry out all measures for prevention of infectious diseases advised by the medical authority; he is faithfully to observe and execute all lawful orders of the Local Government Board which may be hereafter issued.

Such is the modern Civil Engineer, when attached, for purposes of local government, to a sanitary authority, urban or rural.

I should not presume to speak on so wide a topic, but that my attention has been drawn to it from boyhood. While still a student at the University I was much impressed by examining the gigantic arrangements for supplying ancient Rome with water, and by traversing along its whole length the splendid aqueduct on the north coast of Africa, which, taking its rise on the hills of Zagouhan, supplied a vast stream to Udina and to Carthage. I venture to show you various sketches illustrating this great work, made on the spot nearly forty years ago. Your attention should be drawn to the sketch in which the source of the stream in the side of the mount is shown. It is remarkable that round this a spacious and solid edifice was raised, showing with what religious care the source of the water-supply was protected from contamination. Not long

after, during a residence of some weeks in Holland, the skill and engineering triumphs of that strange and noble country filled me with admiration. Chance fixed me in a professorship here, and I was forced by the Local Acts to be officially a Street Commissioner. What a contrast was then found by me to those works which had so instructed me in Rome, Carthage, and Holland. An undrained town in a sodden valley; a foul and filthy water-supply; and no power to obtain money to remove these evils. Still worse, there was an administrative Board unfit and unable to cope with the evil, or appreciate the risk. It would be a strange tale for those who think that we are not improving, if the complacency were described with which men then lived on a site, which, we now know, needed but a chance combination to decimate it with typhoid. The town was riddled with cesspools, in the midst of which the shallow wells were dug. The water-works pumped up, with an uncertain and infirm water-wheel, a liquid fouled by the overhanging privies and filthy ditches of the slums of the city. There was no systematic drainage. What drains there were were rudely executed in gaping brick. By a special engineering effort, a sewer was constructed from the north to the south of the town. When completed it flowed the wrong way, and was abandoned. I forbear to describe the cesspools under kitchens and in entrance halls; the alleys, the houses. An upper floor in one dwelling served as a fancy dog-kennel, which I saw filtering its filth through the rotten floor on to the bed of a woman in labour in the room below. The tenement belonged to an elected, not an official, Street Commissioner. At length the Local Acts were abolished; the Imperial Acts were adopted; a Local Board was formed; and Mr. White has shown you the outcome in our drainage works to-day.

Steadily, if slowly, the Local Board is doing its work. Every year the number increases in the district, who have mastered the sanitary problem to be worked out in this country. We have as the assiduous Chairman of our Drainage Committee one of the first scholars of the age, Dean Liddell. Many now know well that the regulation of the surrounding flood-waters; the purification of the Thames and the Cherwell; the distribution of the sewage by irrigation; the destruction of bad courts and of cesspools; the erection of proper dwellings; all, in short, of the requirements of a healthy town, are to be steadily aimed at, and at the earliest moment secured. Yet progress cannot be always rapid. One of the wealthiest colleges, the chief landowner of the best building-sites of the town, has felt itself compelled to allow the

erection of whole rows of villas without sewers or safe water-supply. It has thereby riddled the before virgin gravel with cesspools and wells, as in the arrangements of old; and left some unhappy householders to awake from their dream of possessing perfect modern dwellings, and to find various maladies occurring, from the combination of bad workmanship with imperfect drainage. An important public functionary also laid out rows of dwellings for the poor in all but undrainable meadows.

These circumstances are alluded to because they are an illustration of what goes on in many places, and are therefore of general interest. For we must not conceal from ourselves that the complete sanitary administration of a densely peopled state is fraught with much difficulty. Look once more at Oxford, as an illustration. It was pointed out twenty years ago that the management of every river basin as a whole is essential for the several towns on its banks. Though many riparian owners on the Thames have done much, and are spending much, Father Thames still goes his own way. He is still fouled by his neighbours; he still floods them in revenge; he still wastes his waters at his will. Would this have been tolerated in Holland, even two centuries ago? Are we to have over Dutch engineers, as once in the days of Vermuyden, to confine him again to his banks? Will Mr. White's costly works keep the cellars of St. Ebbe's and St. Thomas's dry, or will they still leave the floods to permeate the subsoil of the lower parts of the town?

We may answer to this, that there is every hope that the Duke of Marlborough's Commission will bring to practical effect the work on which it has been now long engaged. The rate about to be levied for the survey and other expenses, will inaugurate a complete system of water regulation in the Thames Valley. At all events, English engineers are ready, when they return from their Dutch engagements, to undertake our minor work here.

These circumstances, connected with the place in which you meet, have only been introduced to illustrate the subject before us: "The Relation of Modern Engineering to Public Health and to Local Government."

In the case of all towns, such as those comprised in the Thames Valley, there is, over and above the ordinary work of town management—such as laying out streets, erecting houses on healthy models, and constructing sewers—both the draining of the surrounding districts and securing an uncontaminated and ample water supply.

A memorial was drawn up in 1862,* urging the Government to attend to the *regulation* of the waters of the Thames, not to the *purification* only, but to the storage at one time and the liberation at the other, as afterwards recommended by the Commission of 1869. This cannot be effected without a united superintendence for the area of the whole valley. The plans of one Superintending Engineer must be followed through the whole basin, in the tributaries as in the main channels. These plans could not be carried out without competent, well-trained local Sub-Engineers, acting under the Local Sanitary Authorities and in harmony with each other.

The superintendence of wisely-devised sanitary areas for engineering purposes should be like the organization of one of our best railways, viz. into districts or sub-districts, with connected supervision of the whole.

There are, therefore, many points to which the attention of an Association of Sanitary Engineers may be usefully drawn: a few may be named.

An Association may help to impress on the public the detailed as well as the comprehensive character of Sanitary Engineering, which has at length become a special and important profession, and bids fair to rival in magnitude, though we hope not in cost, the development of railway engineering thirty or forty years ago.

On the *details* of sanitary work it would be impertinent for me to enlarge. Yet, speaking as one of the public, I may remark that a very short time since, architects and surveyors often undertook sanitary works with very imperfect knowledge of what had been done, or of the skilled contrivances which existed. This Association will do good service by interchanging and making public the details of their experience. Many useful contrivances, such as those made years ago by Clark of Carlisle, and many of the fittings introduced by Jennings, existed long before they were generally used. We spent much money here on bad fittings years after good ones were in the market. But this stage has passed, and we have another danger ahead — the danger of advertised and spurious wares, "floated" under many names, and processes which have not a shadow of scientific foundation; various will suggest themselves to your minds. This is the more to be regretted, because no profession affords so many instances of valuable contrivances, either the propoundings of untaught men of genius, or the result of

* See Note II., p. 22; and compare Resolutions 23 to 26 of 'Second Report of Royal Sanitary Commission,' p. 176.

scientific culture by true experts. I will name three: the arrangement for dividing overflow water by the property of its velocity—applied, as I understand, first by Bateman in the Manchester Waterworks;* the method of laying sewers in straight lines from man-hole to man-hole, a plan, I believe, devised by Rawlinson (whose name I cannot mention without esteem as well as respect); and the scraper for internally honeycombed iron pipes, invented by William Froude,† the outcome of consummate knowledge and masterly powers of observation.

When we see great results produced by such simple methods, we do not despair of the sanitary arrangements in houses and cities becoming very shortly reduced to an absolute certainty, when every district has its Superintending Sanitary Engineer, versed in the best knowledge of the time, and a staff of conscientious workmen, such as our modern works are already educating.

The details are almost all known. That sanitary pioneer, Chadwick, has lately summarized the wants of the house to be weather-tight, damp-proof, miasma-proof, with warm fresh air, unwaste, fuel warming apparatus, safe water-supply and sewerage, *within;* and an authority to remove refuse, and dispose of it with economy and safety, *without.* And so in the case of large collections of houses, i. e. Cities, Mr. Rawlinson has, in his masterly way, sketched 'Suggestions for Main-sewerage and Water-supply,' on the principles which most skilled borough engineers now apply. Gigantic works, indeed, are in operation or progress in every direction. Above all, the good sense and determination of the country is heartily embarked in the work.

Every place has its sanitary authority, composed for the most part of elected residents—would they were always selected also; and every place, the Metropolis excepted, has but one authority. We have entirely passed out of the stage of needing proof of the evil of insanitary conditions. We are in the hands of the executive. We have to find out the cheapest form of permanent staff to carry out the instructions which accumulated biological knowledge and experience demand. The Medical department of the Local Government Board will always have that knowledge. It is a knowledge

* See the notice in the useful work of Baldwin Latham, 'On Sanitary Engineering,' 1874; or in 'Description of Manchester Waterworks,' by I. F. Bateman, F.R.S., 1866.

† 'Report of British Association,' 1869, p. 210. The scraper travelled successfully from the edge of Dartmoor to Torquay, being heard at its work the whole way.

only to be obtained by skilled experts, giving their lives to its acquisition. Like most other knowledge, when obtained, it may be handed on in a clear and intelligible form to all willing learners.* The advising inspectors, and our highly instructed periodical literature, are making all such sound knowledge common property, possessed by the most intelligent persons in even remote districts.

Next, with respect to the comprehensive character of Sanitary Engineering. The Royal Sanitary Commission urged, and urged with effect, that there must be a Sanitary Authority for every spot, and but one authority. This now is law. But it further advised that the areas of the authorities should be re-adjusted. This is partially done, though it might have been better done. Medical officers can be appointed to areas of any size whatever, according to the conditions of the localities, and with the approval of the Central Board.

These two principles—the having even every hamlet under proper sanitary care; and the power of combining areas into the most suitable dimensions, according to the population, and the physical conditions of the districts—lie at the root of the whole question of national sanitary arrangements.

But we may see at a glance that these principles touch not only the details of local taxation and administration, but the mode of imperial supervision of any national funds given in aid of local sanitary work.

It is greatly to be regretted that popular writers do not always note this. They often blame government for not settling by a stroke of the pen what touches every local interest and property in the country. So large a question has unavoidably baffled, as yet, every statesman who has approached the subject; but every Session of Parliament throws light upon it, and brings us nearer to a solution. For my own part, I retain the conviction of many years, that the true policy for securing the national health, lies in the steady education of the people, to take a thorough and intelligent interest in perfecting, under local management and central or imperial advice and supervision, their local sanitary arrangements.† I am more convinced than ever, that coercion, even if attempted, will in the end retard progress. Theorists may dislike the political

* See the 'Instructions for Medical Officers of Health by the General Board of Health,' 1848; and the same of the Local Government Board, 1874; and those to Inspectors of Nuisances, and many local acts and bye-laws. See also Note I., p. 18, as to functions of Local Government Board.

† See Note I., p. 18, as to functions of Local Government Board.

truth, that in this country neither the government, nor the people, separately from each other, direct public opinion, or make public law: it is discussion, and action and re-action, between the two, which bring about among us stable progress. Practical life in England does not rest on logical science.

The profession of Engineering is one which above all others has been self-made, without the trammels of regulations. This has been at once a source of strength on the practical side, and of danger on the scientific. But without pursuing that subject, it must be admitted that the sanitary engineers of the future will need as much consideration in a perfect sanitary organization, as the legal or the medical department. It will be for the engineering profession itself to see to the training of its students, the due supply of its ranks, and the guarantee for the fitness of its members.

The public grievously need some guarantee. Health authorities have often been put in difficulty to know in whom they can place their trust, whether they seek for knowledge to guide them, or high character to keep down expenditure.

History has shown that much bad work has been heretofore done, either from lack of training or want of experience. Much money, too, has been squandered, because the interest of the employer has not always been the first object in the execution of works. There are many remarks worthy of attention on this subject in the writings and autobiography of Sir John Rennie. But, this being said, it is right to add, that probably there never was a time when it was as easy as now to obtain competent and upright men for the superintendence of sanitary work.

It will go far to reconcile England to a thorough re-distribution of areas for purposes of local government, and the establishment of a complete executive for the objects of preventive medicine, if the people are convinced that no works are advised which are not really needed, and that none are taken in hand which are not faithfully executed in respect of durable workmanship, and carefully controlled in respect of cost.

For this end, as in other departments, but two things are necessary: the average knowledge and good sense of the practical men of a district for all local purposes, with highly-skilled imperial inspectors occasionally to advise and assist. The germs of this system we already have in both the medical and engineering departments. A few years more, and we may hope to see the full

harvest of our experience gathered in, and a thickly-peopled country for the first time parcelled out into areas, where all that can be done for health is done, and nothing done which is needless or fantastic.

Lastly, in a memorandum in the Report of the Royal Sanitary Commission, the "National or Chief Health Office," or the "Local Government Board," is said to be divided into six departments:

1. Legal.	4. Poor Relief.
2. Engineering.	5. Medical.
3. Statistical.	6. Medical Legislation.

In the Public Health Act of 1875, by far the greater number of clauses are necessarily devoted to subjects purely legal. Comparatively few are needed for the direction of the constituted authorities in respect of the Medical Officer of Health, or of the Engineering Officer of Health. Every authority is obliged to appoint both, as well an Inspector of Nuisances; but either of the two chief officers may act in the last capacity also.

The Engineering Officer or Surveyor has a very onerous duty. He has to execute and maintain what the science of medicine suggests as desirable to be attempted, to enforce and maintain cleanliness, and to provide pure air, pure water, dry and pure dwellings. All this is to be done, as far as the conditions of our climate and nation permit, for every site in the city; from the crowded alley to the palace; for every cottage on the hill-side, and for the princely, but often dangerous, dwelling, an English country seat.

There is a great future for the Sanitary Engineer in this country. The Institution of Engineers proudly boasts, that it aims at "directing the great sources of powers in nature for the use and convenience of man." Well have the British engineers striven to this end. They have invented countless machines for useful and countless ends;* have constructed all over the world railways and bridges, opening up unknown and before unattainable regions; having built lighthouses, and docks, and ships, with scarce a rival; and, lastly, they have begun a yet more useful work, more necessary, more blessed, soon we hope to be one more gem in their professional crown—they have entered on the search after the most economical means for providing a healthy home for every man, rich or poor, according to his wants, his place, and his con-

* See the Preface to the first volume of Smiles' 'British Engineers,' a book which those who are inclined to despair of England had better read.

dition; and thus, hand in hand with the longed-for progress of education, morality, and culture, they will make possible a virtuous and happy fireside for crowded and toiling millions.

NOTES.

I.

THE following extracts from the Memorandum printed in the Report of the Royal Sanitary Commission, tending to illustrate some of the functions of the Central Office, may not be out of place here. They are found in full also in 'National Health,' by Dr. Acland (James Parker and Co., London, 1871, Second Edition):

§ 1. The duties of the medical officers of public health must necessarily be considered in connection with several complex questions of central and of local administration.

The Commission has unanimously come to the conclusion that every question affecting public health should be brought into relation with one central office, presided over by a minister. Every health officer would thus stand directly or indirectly in official relation to such a minister.

§ 2. It has been further decided that every district, urban, suburban, or rural, should, in respect of its public health, be as closely connected with the said department of health as is every part of the country with the Home Office through the police and the magistrates, and as are the destitute with the Poor-Law Board through the guardians of the district in which they are resident.

In short, that every person shall henceforward be entitled to such reasonable public protection in respect of his health as he is in respect of his liberty and his property. For instance, he shall no more be liable to have the water of his well poisoned by the neglect of his neighbour than to be robbed with impunity.

And he is to be under this protection, as far as it is reasonably attainable, everywhere and at all times.

The *first* principle, therefore, of sanitary administration is that no member of the community shall wilfully or for profit damage another man's supply of the three absolute essentials of life, food, water, and air; and therefore that it is the duty of the State to secure, as far as possible, that these essentials shall be supplied, in sufficient quantity, and the greatest attainable purity, in all circumstances in which these objects cannot be attained by individual care and resources. In this

point of view it may appear a question whether the State should allow that any man, even by prescription, shall be held to have acquired the right to pollute, for his own advantage, another man's food, water, or air, or in any manner poison him. At any rate, care should be taken that no one shall acquire such right in future.

The *second* requirement of sanitary administration is universality, through constant supervision by public health officers in every part of the country.

The efficiency of the agents in sanitary administration is as important as their ubiquity.

They must be well-instructed and capable, without the pedantry or officiousness of sciolists. Ignorance, pretentiousness, or over-meddling on the part of the agents would bring into disrepute any sanitary system. In a free country disrepute would bring about failure. Fitness in the agents is the *third* requisite in sanitary legislation.

Though an all-pervading system of sanitary experts be thus necessary for a densely-peopled community, living in artificial or non-natural conditions singularly unfavourable to health, yet the very exigencies of such a community make it unlikely that in this country any costly system of sanitary inspection can be established at present; any proposed system must therefore be economical. Though at present the State must spend great sums on experimental armaments and weapons of destruction, it may hesitate to make costly experiments for the prevention of possible or contingent sources of ill health. Those who are strong doubt the necessity, those who are sick—happily the minority—have not power sufficient to promote great schemes. Economy is thorefore the *fourth* essential principle of Sanitary Administration. . . .

* * * * * *

It must be remembered that the inspectors who will be responsible for local sanitary administration have collectively, if not individually, to administer Acts* bearing on the following subjects:

§ 10. 1. Plans bearing on sanitary engineering or on local government, i. e., drainage, sewerage, water supply, baths and washhouses, nuisances, offensive trades, smoke, public places of recreation, streets and roads, buildings, cellars, and lodgings, burial-grounds, mortuaries, appointment of officers, artisans' dwellings, labourers' dwellings.

2. Care of personal health and safety, i. e., health in factories and workshops, mines, bake-houses, dangerous occupations.

3. Regulation of quality of food, i. e., adulterations, markets, diseased cattle, slaughter-houses.

* See Glen on 'Public Health and Local Government Laws,' and Baker on 'Laws relating to Public Health.'

4. Medical, i. e. prevention of disease, epidemics, endemics, syphilitic disease, small-pox (vaccination), quarantine, lunacy, hospitals,* whether first rate supported, such as workhouse hospitals, or hospitals under local boards; or secondly, voluntary, whether general or special, endowed or subscriptional, county or small village hospitals, or hospitals for the insane, and prisons, sale and adulteration of drugs, poisons, supervision of reports of officers of health.
5. To which must be added medico-legal arbitrations. . . .

* * * * * *

There should be—

I. A Minister of Health and Local Government.

II. Six (Five, 1876) permanent departments under the Minister for—

a. Law of local government.
b. Engineering.
c. Registration and statistics.
d. Relief of poor.
e. Medical care of public health and poor.
f. Legislation bearing on the profession of medicine.†

III. A body of inspectors attached to the Health Office. These are to be of two kinds, as at present, with a third body of consulting experts.

1st. General inspectors attached to, and generally residing in, the "registration divisions," "poor-law districts," or (as they will also be) "public health areas."

2nd. Special inspectors, viz., legal, engineering, scientific, and medical.

3rd. Special experts whose names should be attached to the Office, and who should advise professionally on special points for special fees; such persons to be appointed for five years and re-eligible.

4th. There will be required local clerks of unions, and of town councils, local surveyors under local boards and unions, local public health (medical) officers of local boards, unions, parishes, subordinate executive officers. . . .

All reports bearing on public health will be connected one with the other, mutually illustrating each other. They will cover the whole ground of the science of prevention of disease, which has become both so important and serious for the well-being of old and

* The whole question of the grounds of admission into rate-supported hospitals must be reconsidered by the Legislature. In Ireland the best results have ensued from the admission on payment of any persons suffering from fevers or severe accidents.

† This should remain with the Privy Council.—(H. A., 1876.)

densely-peopled countries. The connection of the office of the Minister of Health with the medical profession, 4000 members of which would be in direct relation to him, would in itself be beneficial to the whole country. It would disseminate established scientific knowledge uniformly through the country districts, affecting not the medical man only, but the clergy and the schools, doing in that way alone as much at least as direct legislation for the same purpose could do. It would bring to light in every corner all that could be advanced as bearing on the physical condition of the masses of the people, while all crude theories or impracticable plans would instantly fade before the experience of the Central Office.

The publications of the statistical department would exhibit what could be shown of the progress of sickness. They might give also useful deductions from local meteorological and scientific observations in connection with those of Kew, the Government Meteorological Office, the Meteorological Society of Scotland, and other sources. . . . .

Great encouragement should be given to local public health officers to send in any observations which would promote the progress of accurate knowledge.

The British Public Health Reports thus constructed, printed in an uniform 8vo form, stitched in a plain distinctive wrapper, and issued in five parts—legal, statistical, engineering, medical (including medico-legal), and general papers of inspectors—would be a series of great value. The Central Office should, immediately on the first issue of the collected series, make arrangement for regular interchange with all foreign countries of similar reports, according to the established usages of academies. These documents should be accessible for reference in the public health library of the minister to all persons connected with the department.

Public Health Laboratories should be maintained or aided by grants from time to time. In them not only points bearing on the general pathology of man and animals would be from time to time investigated under the best guidance, but persons would be trained to be thoroughly qualified in all medico-legal questions. Hereby some of the scandal of *ex-parte* scientific witnesses might be checked or removed. Such laboratories should be aided or maintained as well in the Metropolis as in some of the great Towns where scientific institutions and medical schools exist, e. g. Oxford, Cambridge, Birmingham, Leeds, Newcastle, Bristol. These centres are conveniently situated for various sections of the kingdom . . . .

* * * * * *

Doubt has sometimes been expressed whether the ordinary medical practitioner is sufficiently instructed in preventive medicine. Such doubt would soon prove unfounded if the organization we propose

were adopted. The medical officers under the Poor-Law are perfectly able to fill up returns, make reports when called upon, point out cause of ill health, and superintend such remedies as the central authority may suggest or direct. No ordinary medical officers should be expected to discharge the duties of the police, the lawyer, or the engineer. . . . .

* * * * * *

II.

Memorial concerning the Regulation and Purification of the Thames Waters.

1. *Whereas* the Area of the Thames and its Tributaries may be computed to contain 6000 square miles, and extends over parts of the several Counties of Essex, Kent, Middlesex, Surrey, Hants, Berks, Wilts, Oxon, Bucks, Herts, Warwick, Northampton, and Bedford;

2. *Whereas* it is highly expedient to regulate the waters brought down by the river Thames, so that they shall be as fit for use and as little contaminated as may be, both in the district immediately above London and in the neighbourhood of all towns on its banks;

3. *Whereas* no systematic provision has as yet been made, either for regulating the several branches of the waters in the Thames Basin on a common plan, or for deterring the Towns on the several parts of it from casting their sewage into the streams; and *whereas* many Towns situated above the Metropolis, viz. Richmond, Staines, Windsor, Maidenhead, Henley, Reading, and Oxford do so cast in the whole or parts of their sewage;

4. *Whereas* it is admitted that besides the injurious pollution of the waters, waste accrues from the loss of sewage;

5. *Whereas* the unregulated action of floods inflicts damage on many lands adjoining the river, and is injurious to the Health of the District;

6. *Whereas* it is certain that these evils would be greatly abated, and the Public Health improved by a more complete and systematized management of outfalls, dams, and sewers than is at present possible;

7. *Whereas* also a Report on the Thames Basin with reference to these several particulars would establish principles applicable to other river systems, and besides improving the water supply of the Metropolis, would yield much information bearing upon the Public Health, and of service to the nation at large, and may properly be therefore esteemed a national object.

THE UNDERSIGNED solicit the GOVERNMENT to issue a COMMISSION OF INQUIRY, or to cause full inquiry to be made in such way as they may see fit, into the condition of the Thames and its tributaries (the immediate district of the Metropolis being excepted from such inquiry, as already under special jurisdiction); to INQUIRE what defects exist; and to REPORT what remedies can be applied to such defects; having regard generally to all purposes by which the River and its branches, or lands adjoining to them, may be improved; but specially to the purification of the Thames waters for the use of the Metropolis and of the Towns in the Thames district, as well as the amendment of the Health of the Population which adjoins them.

(*Signed*)

EDWARD SABINE, *President of the Royal Society.*
RODERICK MURCHISON, *Director-General of the Geological Survey.*
RICHARD OWEN.
C. B. ADDERLEY.
WILLIAM HEATHCOTE, M.P.
GEORGE GRAHAM, *Registrar-General.*
WILLIAM FARR, *Somerset House.*
THOMAS WATSON, *President of the Royal College of Physicians.*
NEIL ARNOTT, M.D.
WILLIAM A. GUY, *King's College.*
R. DUNDAS THOMSON, F.R.S., *Health Officer Marylebone District.*
JAMES CLARK.
ROBERT RAWLINSON, C.E., *Local Government Office.*
STRZELECKI.
CARNARVON.
S. OXON.
J. RANDALL, *Archdeacon of Berks.*
FRANCIS JEUNE, *Vice-Chancellor of Oxford.*
HENRY G. LIDDELL, *Dean of Christ Church.*
HENRY W. ACLAND, *Regius Professor of Medicine.*
JOHN PHILLIPS, *Professor of Geology.*
B. C. BRODIE, *Professor of Chemistry.*

And others.

May 28, 1862.

The invaluable Reports of the last fifteen years from the several Committees and Commissions, on Sewage, Pollution of Rivers, the river Thames, and Water-supply, more than justify every clause of this Memorial.

A cordial vote of thanks having been given to Dr. Acland, the Members and several visitors drove to the Waterworks, where they were received by Mr. J. Galpin, Chairman of the Committee, and Mr. Downing, Engineer and Manager, who explained the pumping machinery and reservoirs.

The Members proceeded, under the guidance of Mr. White and

his staff, to the drainage works under the Castle Tower, the tunnelling for which had been completed through to Titmouse Lane, a day or two before. The underground works and various appliances exhibited in the Castle Garden having been duly inspected, the party walked along the line of sewer to St. Aldate's, examining the works in progress; then drove to Iffley and viewed the outfall sewer-works going on there; after this to the pumping station; returning from which, the tour ended in Christ Church Meadow, at the point to which all the city sewage will converge at the eastern end of the Broad Walk. Here the completed works were brilliantly lighted, and convenient provision being made for descent, an opportunity was afforded of viewing internally the sewers under a head of water, much increased by the high flood; and also the tubes under the western branch of the Cherwell.

The long straight line stretching from this point to St. Aldate's, and passing under Trill Mill Stream between, was particularly well shown up by candles ranged along either side for the whole length, the vista being closed by a powerful railway signal lamp.

The Members expressed great satisfaction at the way in which all the works were done, and their sound and stable character.

The operations of the day terminated by a dinner at the Clarendon Hotel under the presidency of Mr. Angell; among the visitors were Dr. Acland, Capts. Galton and Sturt.

MIDLAND DISTRICT MEETING.

The ninth meeting of the district Committee for the Midlands, was held on 19th April, 1876, at the Court House, Warwick. The Mayor (Alderman Nelson) presided, and there were also present Mr. G. W. J. Repton and Mr. A. W. Peel, the Members of Parliament for the borough; Mr. E. Pritchard, C.E., Vice-President of the Association; Dr. Wilson, F.C.S., Medical Officer of Health for Mid-Warwickshire; Dr. Swete, F.G.S., Medical Officer for Droitwich; Alderman S. T. Wackrill (Mayor of Leamington); Aldermen Tibbits, M.D., and Glover, Warwick; Councillor Smith, Alderman Roden, M.D., ex-Mayor, Droitwich; Major Lampriere, R.E., Warwick; Messrs. T. Lloyd, Warwick; J. C. Mellis, C.E., F.G.S. (late Government Commissioner at St. Helena), Kenilworth; W. Boon, S. Vale, Coventry; J. W. Kirshaw, F.G.S., A. J. Ingram, J. Boddington, R. Dodd, E. Davis, R. C. Heath, A. Fairlie, T. Green, T. Warren, Warwick; E. Marshall, Smethwick; and the following members of the Association; Messrs. F. Ashmead, Bristol; E. J. Purnell, Coventry; R. Davidson, Leamington; T. T. Allen, Stratford-on-Avon; G. Cole, Hereford; G. F. Smith, Milverton; B. H. Valle, Stow-on-the-Wold; C. Jones, General Secretary, Ealing; and J. W. Fereday, Wednesbury. Letters of apology for non-attendance were received from Lord Brooke; Professor Acland; the Mayor of Stratford, Dr. Nason; and many members of the Association.

The minutes of the last meeting, held at Oxford, were read, and on the motion of Mr. Ashmead, seconded by Mr. Davidson, were approved.

THE WATER SUPPLY OF WARWICK.

Mr. E. Pritchard (Vice-President, and Engineer of the works now in course of construction at Haseley) read a paper on the Warwick water supply. A number of large and carefully executed diagrams and sections, which had been made by the author of the paper, were used by him to explain the various works referred to.

WARWICK WATER SUPPLY.

By Mr. EDWARD PRITCHARD, Assoc. Inst., C.E.,

The town of Warwick occupies an elevated site, and is situate on the new red sandstone formation; its altitude ranges from 150 feet to 235 feet above the mean sea level. The population of the Borough is 11,000, and the rateable value 43,334*l*.

A small portion of the town prior to 1852 was supplied by water pumped from the Priory Pools by a water-wheel, through a small lead pipe rising main; the distributing mains being chiefly constructed of wood. This supply proving inadequate, the Corporation decided upon obtaining a more complete scheme for the town, for which purpose Messrs Rammell and Lister, Civil Engineers, were instructed by them to prepare the necessary plans, levels, &c. The Engineers very naturally directed their attention to the high lands adjacent to Warwick, for the purpose of obtaining a supply for the town by gravitation; and they reported favourably to the Corporation respecting two sites.

The first site selected was the "Hatton Hill," a cutting on the Great Western Railway, four miles from Warwick in the direction of Birmingham. This is a deep cutting through an immense drift of sand and gravel, and from which the Railway Company obtain a considerable quantity of water for the supply of their stations and engines. The level of this spring was said to be 155 feet above the river Avon, and 60 feet above the highest part of Warwick. In consequence of difficulties with the Railway Company this scheme was abandoned.

"Haseley" (which is in close proximity to Hatton) was next selected, and the Engineers say in reference to this:

"The immediate spot from which we now propose that the water supply of Warwick should be obtained is not far distant from that previously recommended (Hatton). . . .

"The upper part of the Hinchford brook, at Haseley, is the point to which we propose to have recourse. The natural flow of this brook in dry seasons being insufficient for the requirements of the town, we propose to impound a portion of the excess of flow in

rainy seasons, to provide against deficiency which might otherwise be experienced."

Below is the analysis of the water given by them:

Silica	·850
Iron and Alumina	·053
Sulphate of Lime	·143
Carbonate of Lime	6·095
Carbonate of Magnesia .. :	5·749
Sulphate of Soda	1·516
Chlorides of Potassium and Sodium	1·480
Grains per Imperial Gallon	15·880

This was, however, rejected, although strongly supported by a section of the Corporation, who considered it the most eligible scheme.

Disappointed in both places, and apparently relinquishing all further thought of obtaining a supply by gravitation, the Engineers endeavoured to obtain a supply from the new red sandstone, for which purpose they selected a site on the east of the town, near to the Union Workhouse; and after boring to a depth of over 400 feet at an expenditure of about 1100*l.*, they abandoned the works in consequence of the smallness of the quantity and saline character of the water. The strata passed through consisted chiefly of red marl (argillaceous and gypseous beds of the new red sandstone). The diameter of the bore was 12 inches.

Failing in their attempt to obtain a supply from the new red sandstone formation, the Engineers, as if in despair, resorted to the river Avon for a supply; the river at the time receiving the sewage from Rugby, Coventry, Kenilworth, and numerous villages on its banks; as also at times the sewage from Leamington. The water (although I cannot find any record of any analyses having been made) was evidently considered sufficiently pure; for a scheme to supply the town was at once prepared and adopted by the Town Council acting as the "Warwick Local Board of Health." In 1853 tenders were received, and the works soon afterwards commenced. The works of water supply and sewage being carried on simultaneously, were completed about the year 1857.

Water Supply.

I will now briefly describe the existing water supply to the town of Warwick, which, excepting some slight modifications, is the same as designed and carried out by Messrs. Rammell and Lister, the engineers before referred to.

Intake.

The water is abstracted from the river Avon, near to the Portobello bridge, contiguous to the confluence of the rivers Avon and Leam, and is conveyed by means of a 24-inch circular brick conduit to the filter beds. It then passes through a filter medium of sand and gravel to the pump well.

Pumping Establishment.

The pumping works and filter beds closely adjoin the Portobello bridge. The water is pumped by steam power to the water tower in the centre of the town, 1½ mile horizontal distance, and 180 feet vertically above the water level at the pump well. The engines, which are in duplicate, are "double cylinder Woolf engines," the cylinders having a diameter of 19½ inches and 10½ inches respectively; the length of stroke is 3 feet. Steam is supplied by two Cornish boilers (in duplicate) of the following dimensions: length, 20 feet; diameter, 4 feet 6 inches; diameter of tube, 2 feet. The water is pumped by two 14-inch solid plunger pumps, with double-beat brass valves, 2 feet 9 inch stroke, and connected with the engine by intermediate gearing. From the peculiar construction of the pumps it is impossible to work them separately, and though due provision has been made to work the engines and boilers in duplicate, the engineers appeared to have overlooked the great necessity there existed for the pumps to have had a similar arrangement. Of this latter fact and its consequent annoyance I have had ample proof during the six years that I have had charge; as in case of any repairs being needed the entire works have had to stand, and the town of course during such period without a supply of water. Since the purchase of a steam fire-engine from Shand, Mason, and Co., the celebrated makers, I have on several occasions been enabled, during a temporary stoppage for repairs, to give a partial supply of water to the town by connecting the delivery of the steam fire-engine to the rising main, and by pumping from the well have supplied about 18,000 gallons of water per hour. The rising main at the works is 12 inches diameter, and terminates in 8 inches in diameter at the water tower. It is also the service main, and it will be obvious to everyone that this is a great mistake, for not only does it cause a variable pressure on the engines, but it is also a fertile source of waste. The present supply to the town is about 350,000 gallons per day, which for a

population of 11,000, gives 31·8 gallons per head per diem: this is excessive and clearly points to a very considerable waste. The supply is also intermittent, the engines working only between the hours of 6 A.M. and 9 P.M. Warwick is a water-closeted town, there being about 2000 closets supplied by water; the majority of which are connected direct with the mains by stool cocks.

Cast-iron mains, 12 inches to 2 inches diameter, with sluice valves, fire hydrants and cleaning cocks, are laid throughout the town. The total cost of the works was

	£	s.	d.
Bore hole	£1,066	10	0
Works in Town	13,561	8	7
	£14,627	18	7

The average annual working expenses for the last three years have been 644*l.* 12*s.* 11*d.*, but assuming these works to continue, a very considerable outlay would be necessary to place them in a satisfactory condition.

The reading of the paper was postponed at this point, and after Mr. Pritchard had explained the plans of the works at Haseley, the party proceeded in various conveyances to the spot. Here a careful inspection of the works in course of construction was made, and the object sought to be gained was detailed by Mr. Pritchard.

Upon returning to the Court House the reading of the paper was resumed.

Mr. Pritchard further referred to the existing scheme, and said the water supplied does not appear to have given general satisfaction, as will be seen from an extract from the report of Dr. Buchanan, the Medical Officer of the Privy Council, who visited Warwick in the years 1866 and 1870.

"The Warwick water supply, that was furnished when the general improvement of the town was undertaken in 1856–58, is stated in my report of 1866 to have been found all along in an unsatisfactory state, with 'organic matter in considerable quantity, and some brown particles of organic matter in suspension.' Analysis of the water at its first introduction had shown 28 grains of inorganic matter per gallon; but on analysis in 1865 there were found '35·7 grains of total impurity, with a larger quantity of chlorides than in the early analysis, and 3 grains of organic matter to the gallon.' Thus it appears that the water, never very clean, was already in 1865 being delivered in a worse state than at first. Its present condition is scandalously filthy. The town water, indeed, is so filthy that throughout the town it is regarded as being chiefly

intended for water-closets and for watering gardens. Being softer than any other available water, it is also used for washing; but 'it is often so muddy,' a woman told me, 'that white things can't be washed in it.' Where there is the alternative of a pump, the town water is seldom used for drinking; but it is so used by some families, who usually subject it to such preparatory processes as 'letting it stand till it gets clear,' or 'tying a bit of muslin over the tap to catch the creeping things, that are sometimes three-quarters of an inch long;' though there are some families, less particular or less ingenious, who drink the water just as it comes to them. The alternative pump generally yields clean water; but being supplied from sources only from 8 to 30 feet deep, under and about houses, the chemical character of the water must needs be open to suspicion. Its visible characters were found to vary; the water from some pumps was perfectly transparent; that from others contained fibres and floccule; while from a few it was so thick and foul that even the town's water was drunk by preference.

"There is no difficulty in understanding how the public water supply of Warwick comes to be foul. It is drawn, as before reported, from the Avon, 1½ mile above the town (as the river goes), and 15 miles below Coventry, (40,000 population), the sewage of which town, to the extent of 1,500,000 gallons daily, enters the Avon by a branch stream. The increase in sordid constituents of the water doubtless comes in part from an increased use of Coventry sewers for excrement. The water is delivered to the town by pumping, and the rising main serves also for a service pipe to the districts along its course. Hence very little water gets into the service tank, in a tower on a high part of the town, and the town is in fact only supplied while the engines are at work, and for such further time as the tower tank takes to empty itself of the water that has reached it. It was observed that after the engine had been at work nine hours, there were but 4 inches of water in the tower.

"The waste of water from the needlessly high pressure in the service mains is very considerable, especially as quite unlimited use is made of the water for garden watering. Most domestic taps, too, are of ¾-inch diameter, and the waste from such a tap, left full open, with 100 to 150 feet pressure of water, is something enormous. A comparatively trifling leakage in a privy was estimated to be wasting 2000 gallons a day. Thus it happens that with a nominal supply of 33 gallons a head per day (supplemented by supplies from private wells), the amount of water furnished to

Warwick is insufficient for a constant delivery to houses; and in case of fire during the night, it may easily happen that no water is available to extinguish it. And yet the pumps of the waterworks are going for fifteen hours out of the twenty-four. Schemes for regulating domestic consumption by meter, and of supplying waste preventers to taps outside houses, are now before the Local Board.

"It need scarcely be said that the impure water which is consumed at Warwick has in all probability shared in the production of enteric fever; but this cause could not be satisfactorily investigated apart from other fever-producing conditions, the chief one of which has already been considered. Great improvement is wanted in the quality of the town water supply. Again, it is a question for an engineer how this improvement is to be effected. Here it is enough that I have indicated the apparent causes of the present impurity. A good public supply of water would put the authorities in a position to advise or enforce the disuse of all impure supplies of water from private wells."

The quality of the water still continuing unsatisfactory, I was instructed by the General Purposes Committee of the Corporation in August, 1871, to ascertain if a supply of water could be obtained by gravitation, and to report thereon, after a very careful examination of the high lands adjacent to Warwick, and taking levels extending over many miles of country both north and south of the town.

I reported in the month of September of the same year in favour of the scheme now known as the "Haseley scheme," being in fact a similar one to that proposed by Messrs. Rammel and Lister in 1852 (although at the date of my report I was unaware of the latter fact). I afterwards prepared the necessary plans, sections, and estimates; which, having been referred to Messrs Cawley and Newton, were reported upon favourably by them; application was made to Parliament in the session of 1872 for powers; and a Bill, called "The Warwick Local Board Waterworks Act, 1872," was granted, empowering the Town Council to take lands and construct the necessary works for obtaining a supply of water from Haseley, at an outlay not exceeding 20,000*l.* Having been appointed the engineer, I prepared the necessary surveys, plans, levels, sections, details, estimates of cost, &c., as required by the Local Government Board. The scheme as at first proposed may be briefly described as follows. I say "as at first proposed,"

because from careful examination (hereafter explained) I found it desirable to alter considerably.

Haseley Waterworks (as proposed).

Haseley Mill, which is the site of the proposed point of abstraction of water from the brook, is four miles distant from Warwick in the direction of Birmingham. The level of the brook is 100 feet above the highest surface level of Warwick. Eleven acres of land were to be acquired, upon which the reservoirs, filter beds, byewash, valve tanks, &c., &c., were to be constructed.

The area of the available watershed is 1500 acres; the brook takes its rise at Honily, a place distant from Haseley about 2½ miles. On either side of the road near to the mill it was proposed to construct a reservoir; the one on the west side a depository reservoir, 10 feet deep, to contain 2,116,000 gallons; that on the east side a storage reservoir, 16 feet deep, of a capacity of 19,519,487 gallons; the water would be decanted from the west to the east reservoir, from thence to the filter beds, three in number, one of which would always be at rest. After filtration the water would pass through a brick conduit of oval form, 3 feet 6 inches by 2 feet 6 inches, 1661 yards long. From the end of the conduit the water to be conveyed through a 12-inch cast-iron main 736 yards, along the Beausale, and Birmingham, and Warwick roads, and from thence to the water tower, 4284 yards, through a 10-inch cast-iron main.

The storage, as proposed, would have been equal in 1874 to 270 days' supply for a population of 11,000, allowing 25 gallons per head per diem, due allowance being made for evaporation.

In January, 1872, Dr. Hill, the borough analyst of Birmingham, made analyses of the town water as filtered, and the Haseley brook waters in its unfiltered condition, with the following results.

ANALYSIS OF WATER EXPRESSED IN PARTS PER 100,000.

	WARWICK, filtered.	HASELEY, unfiltered.	BIRMINGHAM, filtered.*
Total Solid Impurity	50·64	29·38	26·36
Organic Carbon	1·08	·320	·320
Organic Nitrogen	·223	·050	·034
Ammonia	·005	·003	·004
Nitrogen as Nitrates and Nitrites	·352	·278	·288
Total combined Nitrogen	·579	·328	·325
Previous Sewage Contamination	32·53	28·10	25·95
Chlorine .. .. :	2·41	2·70	1·42
Hardness	22·20	18·57	14·57

* This given for purposes of comparison.

Dr. Hill states: "That this water in its unfiltered condition is of the same quality as the filtered water at present supplied to the town of Birmingham."

Estimate of Cost.

My estimate for the works, as submitted to the Local Government Board, was as follows:

	£	s.	d.
Cast-iron Mains, Valves, &c.	2,886	6	6
Reservoirs, Filter Beds, Bye-wash Brick Conduit, Fencing, Lead-laying of Iron Main, &c.	10,113	13	6
Compensation, Purchase of Land, Analyses, Legal, Engineering, and other expenses	4,500	0	0
	£17,500	0	0

Statistical Information.

I submitted to the meeting of the Association, held in Coventry in 1874, a tabulated statement containing valuable information respecting the supply of water by gravitation from collecting areas, in which was given particulars of the supply to seventy cities and towns situate in different parts of the United Kingdom, including Glasgow, Dublin, Liverpool, Bradford, &c., &c.

On perusal, it will be found that the quantity supplied per head per diem varies very considerably in different towns, Greenock being at the top of the list with 72; whilst Tydesley (Lane) gives 9·69, the supply for trade purposes being included in both instances. The other cities and towns give: Glasgow, 50; Dublin, 42 (one half of which is said to be wasted); Bradford, 33; Liverpool, 27; Bath, 19; Bury, 15; Keswick, 13; Aberdare, 12; and Huddersfield, 10.

By the adoption of the waste-water meter, a very ingenious invention of Mr. Deacon, C.E., Vice-President of the Association, and borough engineer of Liverpool, the Water Committee have been enabled to reduce the consumption of water in some districts from 33 to 11 gallons per head.

As I have before mentioned, the present intermittent supply to Warwick is over 30 gallons per head per diem; still I am of opinion by careful inspection this may easily be reduced to 15 gallons per head; and that with a constant supply 20 to 25 gallons will be abundant.

Rainfall and Brook Flow.

Daily gaugings (or nearly so) have been taken of the rainfall, and also of the flow of the Haseley brook, since November, 1871, for the purpose of ascertaining accurately the relation of the rainfall

to the brook flow; and I now propose to give the result of my four years' labour, which I trust may not prove uninteresting to you. I have also prepared diagrams to illustrate my paper.

The watershed contributing to the brook at the point of abstraction contains an area of 1300 acres; its superficial configuration is in part undulating, in places hilly; the surface is mostly of clay and clay loam; there is also a considerable tract of alluvial soil, and in the valley, peat. The diagrams represent the rainfall and flow of brook, both monthly and yearly.

Below is the annual rainfall.

1865	=	26·62 inches
1866	=	27·39 "
1867	=	26·71 "
1868	=	25·38 "
1869	=	26·11 "
1870	=	19·51 "
1871	=	24·33 "
1872	=	37·40 "
1873	=	20·91 "
1874	=	21·35 "
1875	=	32·02 "

the average rainfall for eleven years ending December, 1875, being 26·15 inches.

From the above it will be seen that five years are above, and six years below, the annual average rainfall. It will also be noticed that the years 1873–1874, to which I shall again more particularly allude, were exceptionally dry ones.

The following table shows the monthly and annual fall of rain upon the watershed of the Haseley brook, and also the actual quantity of water passing over the weir from an area of 1300 acres.

Month.	1872.		1873.		1874.		1875.	
	Imperial Gallons.	Rain in Inches.	Imperial Gallons.	Rain in Inches.	Imperial Gallons.	Rain in Inches.	Imperial Gallons.	Rain in Inches.
January	129,127,190	4·17	51,677,100	1·60	52,679,230	2·44	68,622,000	1·94
February	50,026,729	1·83	25,689,824	·66	28,457,930	1·49	35,861,536	1·47
March	21,755,701	1·80	65,315,800	2·26	12,543,670	·77	17,948,856	·52
April	44,480,900	2·46	8,103,300	·58	13,785,168	1·37	9,182,024	1·26
May	11,725,300	1·46	13,201,222	2·27	7,365,114	1·62	8,878,780	1·53
June	53,303,800	5·19	9,786,600	2·79	3,695,130	·50	8,086,750	2·50
July	22,380,870	3·43	11,335,280	2·40	3,518,138	·89	56,467,680	6·24
August	29,178,722	3·48	6,208,128	2·35	3,932,174	2·31	6,943,444	2·44
September	7,203,020	1·99	7,568,856	2·07	8,872,282	3·91	11,268,274	2·55
October	30,605,272	3·47	15,047,088	2·11	12,538,132	2·39	121.689.748	6·50
November	97,644,862	4·14	16,748,920	1·27	39,263,124	2·44	145,910,280	4·39
December	89,690,200	3·98	7,891,668	·55	43,668,252	1·22	24,847,600	·68
Total	587,122,566	37·40	238,573,786	20·91	230,318,344	21·35	515,706,972	32·02

It will be found from the above that the quantity of water flowing from off the watershed represented of the total rainfall:

In the year 1872	=	53·2 per cent.
„ 1873	=	38·7 „
„ 1874	=	36·6 „
„ 1875	=	54·6 „

In 1872 and 1873 I had trial holes and borings made on the site, and being struck with the peculiar nature of the watershed, I was led in the summer of 1873 to make further investigations, when I ascertained that there was a considerable accretion of water below the road, or on the east side, and but a very short distance therefrom. Again in the summer of 1874 I obtained such results as to satisfy myself that a very considerable quantity of water might be obtained by tapping the subterraneous reservoir, which in my opinion existed, and so obviate the necessity of constructing any storage reservoirs. As there was a strong feeling in the town that I was not providing sufficient (?) storage, I did not then propose to dispense with the reservoirs. On the 12th November, 1874, a Local Government inquiry was held by J. Thornhill Harrison, Esq., C.E., and I then suggested as a substitute for the proposed storage reservoirs that adits should be driven into the water-bearing strata, which would increase the supply, provide storage, and save cost. The inspector, who had visited the site and carefully considered my suggestion, after having been supplied with detailed information and plans, confirmed the opinion I had formed, and reported favourably to the Local Government Board thereon, an extract of which was forwarded by the Board to the Town Council, in which Mr. Harrison says:

"There is impounded within a natural reservoir an immense volume of very pure water, which, if properly managed, will require no filtration, and in my opinion will yield an abundant supply for the town of Warwick."

Mr. Harrison says in reference to increase of population:

"Allowance should therefore be made for a population of 12,000 or 13,000. Allowing 20 gallons per head, which I consider ample for a town like Warwick, there would be required a daily supply of 240,000 gallons. This, and a much larger volume, if requisite, may, I believe, be obtained from the sand bed by means of an adit."

Haseley Waterworks (as being constructed).

Acting upon my advice, which was supported by so experienced an engineer as Mr. Harrison, the Town Council determined to pro-

ceed with the works forthwith, for which purpose they accepted tenders for contracts, Nos. 1 and 2 being for cast-iron pipes and pipe laying respectively. Commencing at the water tower (which contains, when filled, 60,000 gallons, and is 51 feet over the highest surface level of the town), cast-iron pipes, 10 inches diameter, were to be laid to a distance of 4884 yards therefrom, and terminating at a point situate near Brownley Green; the pipes for this distance follow the contour of the ground, and are placed out of the reach of frost. From this point to the valve tank at Haseley, 1890 yards in length, a 12-inch cast-iron main, laid with a grade of 1 in 283; in consequence of the hilly nature of the ground, this pipe will be placed at a maximum depth of 48 feet below the surface of the ground. With the exception of the deep cutting and tunnelling rendered necessary for the laying of the 12-inch main, the pipe track does not possess any special interest. Sluices, air valves, and fire hydrants are placed at convenient distances along the line. The pipes are being supplied by Messrs. J. and S. Roberts, of West Bromwich, and are coated with Dr. Angus Smith's solution. The sluice valves, air valves, and hydrants have been supplied by the Glenfield Foundry Company, Kilmarnock. Messrs. Doulton and Co., Lambeth, supplied the earthenware pipes, among which were a great number of "Stanford's Patent Joint," which in many instances are invaluable. The pipes have been laid in the ordinary manner with yarn and molten lead joints well set up; sharp bends in every case having been rigidly avoided. The pipes have been carefully tested, in some cases both at the founders and also by the Town Council: the 12-inch being placed under a pressure equal to a column of water in height to 400 feet; the 10-inch to 600 feet. The capacity of the 12-inch main is 1,238,400 gallons in 24 hours; the 10-inch being 950,400 gallons at the surface of ground in the Market-square, and 518,400 gallons at the top of the water tower, during the same time. The contractor for the pipe track was Mr. Charles Hart, Assoc. Ins., C.E., of Leamington, who having at the deep cutting previously mentioned abandoned the work, the Corporation re-let the contract to Mr. G. F. Smith, of Milverton, who is also the contractor for the adits. The total length of main is 6774 yards, being nearly 4 miles.

Construction of Adits, &c.

Contract No. 3 has been let to Mr. G. F. Smith. This contract

comprises the following work:—One 9-inch earthenware overflow drain, 800 yards long, 7 feet average depth; one valve tank, 17 feet by 6 feet, by 6 feet by 14-inch brickwork; one collecting well, 17 feet by 6 feet circular, by 14-inch brickwork; one 12-inch pipe conduit, 500 yards long, 12 feet average depth; No. 1, 15-inch pipe adit, 400 yards long, 21 feet average depth; No. 2, 15-inch pipe adit, 218 yards long, 15 feet 7 inches average depth. I have especially directed your attention to this contract, in consequence of its unimportant appearance upon paper, but which has in reality proved a most difficult work in construction.

The following extract from the specification will explain the method I have adopted in the construction of the adits:—The adits will be of 15-inch perforated pipes; each pipe will be two feet long, and shall be laid upon a platform of elm, where such adit may have quicksand for its foundation. "The platform will be formed as follows:—the trench for its reception having been excavated or driven at the proper level, two runners or longitudinal timbers 5 inches by 4 inches shall be laid upon sand; upon these runners cross pieces of timber 3 feet by 6 inches by 1½ inch, shall be firmly secured by 4-inch iron nails in each piece, and upon the flooring so formed the pipes shall be placed, supported by 1 foot 9-inch by 6-inch by 3-inch saddles properly cut to receive them; there shall be two saddles to each pipe. To prevent sand passing through the perforated pipes, a filter medium of washed gravel and sand, of a thickness of 4 feet 6 inches and 3 feet wide, shall be placed throughout the entire lengths of adits; Nos. 1 and 2 will be formed as follows, under, around, and above the pipes: washed gravel, the size of hens' eggs, 2 feet 3 inches; washed gravel, the size of walnuts, 9 inches; washed gravel, the size of horse beans, 6 inches; washed sand, 1 foot; total, 4 feet 6 inches."

The works which have been constructed in conformity with the above stipulation, although only partially completed, have more than realized my most sanguine expectations, for at the present time 500,000 gallons per day have been obtained of an excellent quality of water, as proved by the analysis of Dr. Swete, Borough Analyst, of Leamington, and also by Mr. Cutting, of Leamington. Fears have been expressed by several engineers of eminence that I should meet with considerable difficulty in controlling the sand. I am pleased to inform you that from the experience I have already gained I now do not share their apprehensions.

In the excavations for the works many interesting geological

specimens have been discovered, including marlstone, with shells (middle lias), granite, chalk, flints, coal measure, millstone grit, quartz, indurated sandstone, &c., &c., clearly pointing to a drift, which in my opinion covers a large area, thus affording an abundant supply of water for a much more populous town than Warwick, by an extension of the works. I have briefly alluded to the difficulties already experienced, and will simply give one or two illustrations, which will, I imagine, suffice. Although the extent of the works may have appeared small, still the contractor (to whom much credit is due for his perseverance) has been compelled to provide a plant of the value of nearly 2500*l.* for the execution of this work; the length of planking required and supplied for piles, barrow runs, &c., representing 41,500 feet, or nearly 8 miles. Again, to sink a pump 7 feet deep by 6 feet, equals 9⅓ cube yards, 56*l.* was expended for labour only, being at the rate of 6*l.* per cubic yard. The cutting, necessary for the laying of the 15-inch pipe, being 49 feet in width, although only a depth of 22 feet, will, I imagine, quite explain the fact that difficulties are being experienced.

In conclusion, I would venture to hope that this paper, written under considerable pressure in consequence of numerous engagements, and only completed a few hours before this meeting, may have proved of some little interest, and that in the visit to the county town of Warwick, it may, on the whole, have proved an enjoyable one, more especially as the first committee meeting of the Association was held in this town three years since.

The Chairman invited discussion on the paper, and trusted some one would find fault with Mr. Pritchard's scheme, in order that he might have an opportunity of defending it.

Dr. Wilson said the subject of the Warwick Waterworks, new and old, was not new to him, but he confessed he had listened with a great deal of interest to Mr. Pritchard's paper, and with no small amount of pleasure to the lucid description which he gave of the works.

He need not enter into details, but as Medical Officer of Health of the borough he might make a few remarks. In the first place, he wished to compliment Mr. Pritchard and the town of Warwick on the prospect of having a full and abundant supply of good water. As Mr. Pritchard had pointed out, the present supply was abominably filthy, and scarcely fit to drink. He was, at the outset,

satisfied that the scheme for obtaining water from the Haseley brook was a very good scheme, but it appeared that it necessitated a large amount of storage, in order to get the supply in dry seasons, and to improve the quality of the water. But it now seemed to him that there had been tapped a supply of water in the drift over the red marl, which, although not rendering them altogether independent of the brook supply, would be little, if at all, affected by the rainfall from season to season. What appeared to him of more importance was that the town was to obtain not only a good supply, but a full supply of water. The dangers resulting from an intermittent supply were very great, and in a town like Warwick, where the water-closets were connected directly with the mains, these were very greatly increased. At the times when the water supply was not going on, the sewage gas escaped from the closets into the mains, and although with a constant supply there was very little danger of this, the waste was likely to be increased. In a town like Warwick, where the sewage had to be pumped on to the séwage farm, an increased expenditure would be caused by the addition of the polluted water, which would have to be pumped up at the sewage outfall. There was no doubt that a third of the water pumped into the town was now wasted, and daily about 100,000 gallons of polluted water had to be pumped on to the farm. He hoped that this question would engage the attention of the Town Council at no distant date. A good point in the scheme was that the supply being constant, the water for domestic purposes would be procured direct from the mains, and would not require to be stored in cisterns. The use of cisterns was a great evil, for they were very seldom cleansed, and from time to time they became foul and unhealthy, and were a source of disease.

In conclusion, Dr. Wilson proposed a vote of thanks to Mr. Pritchard for the able paper he had read, and for the admirable display of drawings with which he had illustrated it.

Mr. C. Jones (Ealing), in seconding the motion, expressed his satisfaction at what he had heard and seen on his visit to Warwick. He was sure it must be pleasurable to all of them to hear a paper like the one they had, with which they could not find fault. The remarks of Dr. Wilson with reference to the dangers resulting from an intermittent supply of water would commend themselves to every mind, and the subject was one of the most important they could impress upon their Town Councils if they desired to decrease the labours of their medical friends. He was also pleased to hear

that polluted water would not be allowed to run down to the sewer outfall in such large quantities.

Mr. Ashmead (Bristol) complimented the engineer upon the scheme as submitted to them, which he considered an excellent one.

The vote of thanks was then put to the meeting and carried.

Dr. Swete (Leamington) said he should like to add his testimony as to the beneficial quality of the water at Haseley, and he thought what he had to say would be of interest to the ratepayers who would have to drink it. He had a number of samples sent to him; and although he was not informed where they were procured from, it was easy to see which was the Haseley water. It presented a great contrast to the water at present supplied. One of the samples was very good, and upon inquiry he found it came from a school, and was procured from the same strata as that they were getting at Haseley, and was, in effect, the same water. They did not expect to find the water from the brook to be of the same class as that from an artesian well driven to a great depth; but the water he analysed was of excellent quality, and had only a very slight trace of organic matter, which, he thought, might be attributed to the filthy habits of the men engaged at the works. Dr. Swete also spoke of the importance of the constant supply advocated by his brother medical officer, Dr. Wilson, and said nothing could express the dangers arising from an intermittent supply.

Mr. Pritchard said he was extremely flattered by the vote of thanks which they had awarded him. Referring to the analysis of water of which Dr. Swete had spoken, he might tell them that one of the samples was taken from the Tangye pump; and although it was very dirty, the analysis showed that it contained in a million parts only ·07 of albumenoid ammonia. That was so small a quantity that he believed the doctor would have no hesitation in declaring it a very good town water indeed.

Dr. Swete said he should say it was a good water.

This concluded the business, and the company adjourned to the Warwick Arms hotel to dinner, under the presidency of the Mayor of Warwick.

APPENDIX.

APPENDIX.

REPORT ON THE SANITARY ARRANGEMENTS OF MANCHESTER, SALFORD, ROCHDALE, HALIFAX, AND NOTTINGHAM.

BY EDWARD BUCKHAM, ASSOC. INST., C.E., BOROUGH SURVEYOR; AND G. S. ELLISTON, M.R.C.S., &c., MEDICAL OFFICER OF HEALTH.

BOROUGH OF IPSWICH.

TOWN HALL, *Feb.* 25, 1875.

To the SANITARY COMMITTEE.

GENTLEMEN,—In accordance with your instructions we proceeded to Manchester, Salford, Rochdale, Halifax, and Nottingham, for the purpose of examining into and obtaining information as to the treatment and removal of excrementitious matter, the system of sewage purification, ventilation of the sewers, and generally to inquire into any sanitary improvements which had been made in these towns, with a view of getting such practical suggestions as would assist us in designing a system of refuse collection suitable to the requirements and circumstances of our own town.

On the first day of February instant we visited Manchester and called upon Dr. Leigh, the Medical Officer of Health and head of the health department of the Corporation, under whose entire charge the night soil collection is carried on. The city contains a population of 351,000, occupying 67,000 houses, using 42,000 privies, 12,000 of which are upon the new system known as the Manchester ash-screening closet, which consists of a building somewhat similar in external appearance to a common privy, but arranged inside with two receptacles separated by a wall. The receptacle for the excrement is a circular galvanized pail, 17 inches in diameter and 13 inches deep. The receptacle for the house refuse is a wooden box, which is about

18 inches square and the same in depth. The refuse boxes are made in different sizes to suit the dimensions of the closet. The screener is formed of wood, and made in a small and convenient form, being in the shape of a box and fixed in a vertical position, either at the side or rear of the seat, but as a rule it is built in the side wall and arranged at such level that the shoot for delivering the fine ashes on the excrement comes just above and in the centre of the pail.

The ashes are put in at the top of the sifter through a small sloping door, and the sifter is so arranged inside the box that the fine ashes pass through and down the inclined shoot at the back into the excrement receptacle. The cinders pass into a small chamber at the bottom with door opening on the outside, where they can be taken out again and used as fuel. Each closet has a ventilating flue, carried up to such a height as may, according to circumstances, be sufficient to take any foul gases above the windows of the house.

The cost of a new closet on this principle complete, exclusive of the two receptacles, is five pounds (5*l.*). For reconstructing and arranging an old midden privy into an improved closet, the cost is four pounds (4*l.*), which is defrayed by the owner. The receptacles are supplied by the Corporation at a cost of 12*s.* per closet, and kept in repair by them.

The Corporation have erected large works with every required appliance for making the sifters and receptacles, and for preparing the joiners' work for the new closets. They appear to have taken the whole thing into their own hands with a determination to alter and adopt all the old midden privies into the improved closets, and at the present time are altering them at the rate of one hundred to a hundred and fifty per week, and at this rate, allowing for the increase of population, the medical officer considers it will take four years and a half to get the system applied to the whole of the city. He is of opinion that their closet can be so improved and arranged that it can be applied to every house throughout the city, to the total abolition of water-closets.

In company with Mr. Wylie, the manager of the night-soil department, we examined the closets in various parts of the city, and found them clean, well arranged, and inodorous, and from the inquiries we made of the tenants they appear to like them much better than the old, ill-arranged and objectionable middens, which we could at a glance easily understand, seeing that as a rule the

yards are small, and in some cases so confined that the closet doors touch the back doors and windows of the houses.

The new closets have been in operation about three years, and the receptacles containing excreta and fine ash are removed once or twice a week, or as often as may be necessary, covered with tightly fitting lids, and clean ones are then put in their places, the rubbish boxes being at the same time emptied into the specially constructed van for carting the pails away. Although conducted in the day time no annoyance or nuisance appears to be caused by the passage of the vans through the streets.

After our inspection of the closets in use we proceeded to the depôt and works of this department, which are situate in Water Street, and are about a mile from the centre of the city. The yard is used entirely for the closet-scavenging department, and as it adjoins the canal on one side, there is every facility for sending away manure by barges, which in a town like Manchester is of great importance.

For the purpose of collection the city is divided into districts, with a certain number of vans and men to each. The vans are constructed to hold twenty-four pails, and are divided into compartments with folding doors on each side, each van is about 2 feet in height and covered by an arched top. There is at the rear of the van an open part to receive the contents of the refuse boxes, supposed to hold refuse in proportion to the number of excrement receptacles carried in the other part of the van. The vans are constructed with springs, and cost about 50*l.* each.

The vans leave the yard with a clean receptacle in each compartment, the time at which they leave being recorded by a clerk who is in charge of a weigh-bridge at the entrance gates. As each van returns with its load of full receptacles, the time is again recorded, the van weighed, and the net weight of excrement and ash entered in a book kept for the purpose. The manager of this department, Mr. Wylie, has a large staff of inspectors under him, who inspect the houses in each district from time to time, and report to him defects in the closets or negligence on the part of the tenants or workmen in charge of the collection, and this inspection is so arranged that no nuisance or defect could exist many days before being reported and rectified.

The excrement and refuse collected in the vans undergo a process of manufacture at the depôt in the following manner. The contents of the pails, when mixed with a sufficient quantity of dry

ash to absorb the liquid, are emptied into a mill, and a certain proportion of animal refuse, in the shape of putrid fish, dead dogs, cats, and offal from slaughterhouses and other places, are added to it. While the manure is passing through the mill about 5 per cent. of gypsum or sulphate of lime is mixed with it, to fix the ammonia caused by the decomposition of the urea and give it a dryer condition. The manure so prepared roughly consists in 100 parts, of about

20	per cent. of	excreta and urine.
20	„	offal and slaughterhouse refuse.
5	„	gypsum (sulphate of lime).
55	„	fine ashes.

After it is thus mixed it passed over a fine sieve worked by steam power, which takes out all the coarse parts, after which it is put into bags and sold at the rate of 12*s*. 6*d*. per ton, in any quantities from a ton upwards to suit customers.

The excrement which has not received a sufficient quantity of ashes to make it dry enough to put into the mixing mill is emptied into a kind of basin made by an embankment of ashes, when fine ashes are added as required to absorb the moisture and make it sufficiently dry and portable to be mixed with the other ingredients in the mill.

The contents of the refuse boxes undergo another process, the dry hard stuff, such as brick bats, broken earthenware, glass, and other similar hard material, is mixed with sand and lime, and ground into powder in a mill, and made into excellent mortar, which sells for 5*s*. 6*d*. per ton.

The old pieces of iron, broken kettles, saucepans, tin cases, and other similar refuse metal, are sold for 25*s*. per ton to the copperas makers.

The old boots and shoes, pieces of leather, woollen cloth, and animal matters of this kind, are disposed of for 15*s*. per ton to the prussiate of potash makers. And the paper is picked out and sold to paper makers, so that nothing in the yard sells for less than 4*s*. 6*d*. per ton.

The old middens are cleaned in the night and the new closets in the day time. The collections from the former are deposited into barges and disposed of at 1*s*. per ton.

The manufacture of the excreta and refuse into manure does not appear to have been commenced more than four months; and carried on as it is in the open air, is certainly very offensive, and must be a great nuisance to the neighbourhood, especially when the

weather gets warmer. To obviate this, three large sheds are being constructed, the centre one to contain the manure and mortar mills, the other two will have two huge tanks into which the vans will at once empty the contents of the pails; the excreta and refuse will then be deodorised with the ashes and manufactured forthwith into manure. It is confidently expected by the authorities that this will effectually prevent the nuisance that now exists. The pails, after being once used, are washed by machinery before being again sent out.

From the number of cinder-sifters now in use the quantity of ash is largely reduced in bulk, and it is expected that in summer the supply will have to be supplemented by the street-sweepings to absorb the liquid excreta in the manufacture into manure. These sweepings, already enriched with horse-droppings, &c., will form an excellent material; and Dr. Leigh estimates that when the whole system is in full working order, not only will the refuse department pay a large profit, but the scavenging of the entire city will be made to pay its own costs.

The Corporation have power under their Acts to cleanse all middens and closets, and to cause the improved closets to be erected both in the case of old houses as well as new, as they may think fit. In case of any owner not complying with their order to erect new closets, they can at the expiration of the time set forth in the notice sue the owner for the penalty provided by the Act, and should he further delay to comply with the notice he is subject to a continuing daily penalty until the work is done. This power is given to them by "The Public Health Act, 1872," and several local Acts. In case they require to do anything for which their Act does not provide, they apply for power as necessity arises.

The present annual cost of collecting from the old and new closets is about 30,000*l.*, but we were informed that this amount will be materially lessened by the improved value of the manure.

We were anxious to obtain detailed particulars of the cost of working, exclusive of all outlay on plant and buildings, but as the manufacturing process has only been in operation about four months they were unable to furnish us with any reliable information as to cost.

The entire cost of collecting is defrayed by the city rate, but for removing all refuse from workshops, mills, and other places, where it is not mixed with excreta and urine, a charge is made.

Shop-sweepings and similar valueless stuff are collected by private persons, who perambulate the town with a bell-cart as a signal for persons to bring out their refuse.

The sale of the manure does not yet pay the cost of collection, but it is expected that a very large annual profit will be derived when the system gets into working order.* They have been, and are still, expending large sums for plant machinery and buildings required to carry on the works.

The sewage of Manchester empties by various outlets into the river Irwell. There is no system of purification whatever, and there must be a certain amount of nuisance arising from such a mode of disposal; but it appeared to us to be difficult to say who produced the most pollution, seeing that, in addition to the sewage of Manchester, the Salford sewage is carried into the same river, and the refuse liquid from dying and chemical works.

The result is that this river, which is not a large one, dividing the two towns, is one long, black, open sewer, which in summer time must be a nuisance to its immediate vicinity, although there was no perceptible nuisance when we were there.

The sewers are ventilated at regular intervals by shafts which carry the accumulated gases above the ridges of the houses. This is more particularly attended to in the higher parts of the city, and in courts, yards, and back streets, all of which are perfectly paved and drained into the sewers. The method adopted is to place a ventilating shaft or pipe at the highest end of the sewer or passage drains, and carry it up well above the eaves of the houses, so as to expose the upper outlet of the shaft to the action of atmospheric currents.

The small houses are not in direct communication with the drains; the sink-pipes are generally taken through the walls and cut off 5 or 6 inches from the level of the yard; and not being directly over the grid or trap, the gas cannot escape into the dwelling. Dr. Leigh also proposes to utilise all rain-water pipes as ventilators as well as flushes; but if this be done they must be perfectly jointed; if not, there would be the danger of sewer gas being drawn into the bedrooms at the escaping point through the windows. The result of the improved closet on the public health has been a slight decrease in the rate of mortality.

The following table by Dr. Leigh will show that the death rate from all causes averaged 27·8 per thousand for the last three

years, whilst the average for the previous three years was 29·3 per thousand.

Year.	Number of Deaths.	Rate per 1000 of Population.
1869	10,232	29·5
1870	9,906	28·5
1871	10,435	29·9
1872	9,551	27·2
1873	10,051	28·5
1874	9,884	27·7
Average of first three years ..	10,191	29·3
Average for second three years ..	9,817	27·8

Dr. Leigh, the Medical Officer of Health, further states that when he came into office six years ago, Manchester was one mass of large, deep, open middens, full of foul liquid sewage, and he calculated, that if these cesspools could have been brought together into one area, they would have formed a lake sixteen times the size of St. Ann's Square, with a semi-fluid mass reeking with the vilest odours, 5 feet in depth, seething and fermenting, and giving off poisonous gases that prostrated the pale and emaciated people dwelling around it with fever from time to time, and carrying them off at the rate of 600 or 700 annually.

It has been the constant aim of the Health Committee during the last three years to abolish these open cesspools, which by overflowing into the drains and sewers of the city began to block them up. Their plan has been before erecting the improved closet, to dig out all the old saturated soil and fill up the cavities level with the surface of the courts and streets, so that nothing but ordinary house drainage can now find its way into the sewers, and they believe that the present adoption of the dry system by small closets, which necessitates frequent removal of the excreta before putrefactive fermentation takes place, will be attended in a few years by the best results on the health of the population.

SALFORD.

On the second day of February instant we called on the Medical Officer of Health (Mr. Tatham), at his office at the Town Hall, who explained to us the dry system of removing excreta now being

tried in the borough, which contains 133,000 inhabitants. It appears that Salford, like Manchester, was full of foul open middens, which tainted the air to such an extent that they had to be universally condemned, and the Corporation undertook to carry out the modified midden system, which consists of a closet and ashpit on the old midden principle, but with the cesspit made much shallower, water-tight, and roofed over to prevent the rain water mixing with the excreta; these are emptied at regular intervals, and although found to be a great improvement on the old horrible pits, round which lurked so much sickness and so many deaths from preventable diseases, still in crowded and confined yards and courts the nuisance caused by empting these places became so injurious that it was evident some more improved system must be tried. The Rochdale tub system was first adopted, but it was found to be so offensive that a cinder sifter was added to the closet to deodorize the contents of the tubs. The closet finally decided upon for trial was Morrell's patent, which consists of a small building, similar to the Manchester one, but instead of the cinder sifter being at the side it is at the back and inside the building. The ashes and cinders are put into the screeners through an opening either at the side or rear of the closet, and in cases where the building is so confined that this cannot be done, they can be put on the screener through a door inside the closet in the wall boarding above the seat. The screener, which has a hopper attached to it, is acted upon by a lever in connection with the seat. When the seat is depressed by the person using the closet it communicates a motion to the hopper which separates the ash from the cinders, the ash falls into the hopper and the cinders at the same time pass down the back of the screener on to the floor, ready for re-use. Upon the person rising from the seat a given quantity of fine ash is distributed over the contents of the receptacle.

The pail is made of galvanized iron, and is 19 inches in diameter and 19 inches deep. It is therefore larger than the one used at Manchester, and is not consequently so liable to overflow, nor does it require emptying so often.

The mode of collecting is precisely the same as in Manchester, and the manufacture of the refuse into manure is carried on in the same manner. The general refuse or garbage box, instead of being inside the building, as at Manchester, stands in a corner of the yard, and is emptied with the rest.

The cost of Morrell's closet complete is from four guineas (4*l.* 4*s.*) to five guineas (5*l.* 5*s.*), and is defrayed by the owners. It is compulsory for persons building new houses, and also for owners of old property, if required so to do by the sanitary authority, to build these closets, unless they elect to adopt the water-carriage system; if they do not comply, the Corporation have powers by special Acts to complete the works required and recover the cost in a summary manner.

Five hundred of these closets have been in use twelve months; they have been applied to seven hundred houses, in the worst localities, representing a population of about 3500 souls; they are emptied once or twice weekly, and in some cases, where there is one to each house, not so often. One van and two men can manage three hundred closets.

The annual cost of collecting has not yet been estimated, but it is considered certain that the proceeds of sale of manure will more than cover the expenses. The removal is made in the daytime, and during the year the effect on the public health has been very beneficial in the localities where the system is in operation; we may add that the closets are guaranteed by the patentee not to get out of order for seven years. Mr. Tatham and his chief inspector accompanied us to several places in Salford and Pendleton, where the system is at work; in Eagle Street, one of the worst places in Salford, where the houses are built back to back, without a scrap of yard; we noticed six of the closets erected in a corner where formerly existed a large open midden; although used by twelve or eighteen families and surrounded on all sides by walls and houses, we found them, considering the neighbourhood, fairly clean and comparatively inodorous. We were told that formerly the smells in this street were so bad, and the place was in such a wretched state of dirt and neglect, that the owners were almost inclined to give the property away. Since the erection of these conveniences the whole place has become altered; each occupier has a key to one of the closets, and another for the place for emptying the cinders and refuse, so that they are closed to the outside public, and from what we saw we are bound to admit that this street, which always had the reputation of being one of the foulest in Salford, was a fair average back street, and free from foul smells.

In another place where each house had a closet to itself, the tenants expressed themselves pleased with the alteration, and although each was erected in a yard 6 feet by 8 feet, with a

high wall at the back, there was no perceptible nuisance; and one woman volunteered the remark that the sifter had saved her one shilling a week for coals during the twelve months it had been there.

In Manchester, Morrell's closet was objected to because it was thought the mechanism would get out of order; but Mr. Tatham states that twelve months' experience disposes of this objection, and he considers the Manchester scheme perfect in every respect, except the construction of the closet; for as the ashes are more regularly mixed with the excreta, there is not the necessity of going to the extra expense of building the high ventilating shaft as in Manchester.

Mr. Fowler, the Engineer and Surveyor to the Corporation, has patented what he designates a "self-acting water-closet," whereby the slop and waste water from the dwelling houses are utilized for the removal of fœcal matter without the use of town water. It consists of an arrangement similar to the ordinary water-closet, but instead of the soil, &c., being carried away by flushing with clean water from the town supply, as is usual in such cases, the slop water from the kitchen sink is made use of for that purpose; this is done by carrying the drain from the sink, and connecting it with the back or side of the closet pan, as shown in the accompanying drawing. The sink water must therefore pass through the trap of the water-closet before it can get into the sewer, and thus takes with it the soil from the closet pan.

These closets have been applied to a small number of houses, and we were informed that they answered the purpose for which they are intended very well.

The sewers empty by different outlets into the Irwell, without any system of purification. An intercepting sewer is now being constructed which will convey the sewage into the river some distance from the town.

ROCHDALE.

February 3.

Up to the year 1869 the night-soil and general refuse in Rochdale were removed by contract, which cost the Corporation about 1300*l*. per year. The removal being very inefficiently and negligently carried out, and there being great difficulty in finding a contractor, the Corporation determined to take the matter into their own hands, and after trying several new methods, finally adopted the one now known as the "Rochdale system."

The closets are on the same principle as those already described in Manchester and Salford; they are built level with the surface of the ground, and are well paved, the principal difference being that a tub is used instead of a pail for the excreta, and a second or larger tub for the ashes, cinders, and refuse. The fœcal and dry refuse are collected separately, the former being removed to the yard in its natural state, without any admixture of ashes to deodorize it.

The tubs, however, which contain it are all covered with tight-fitting lids.

All persons building new houses have to provide the tub closet, and old middens are filled up and converted into the new system at a cost of 2*l.* 2*s.* each. The tubs for the excreta are made out of paraffin and lard casks, and cost 4*s.* 6*d.* each to manufacture. The owner pays the cost in the first instance, and the Corporation keep them in repair. The number of new closets in use at the end of the year 1874 amounted to about 4000, and are emptied once a week; the collection is carried on by eleven vans containing twenty-four receptacles in each, with two men to attend to it and twelve carts for ashes; the vans cost 47*l.* each, and the carts 25*l.* each.

The borough is divided into six districts for the purpose of collection, and each closet is numbered consecutively, so that in case of infectious disease the excreta can be isolated from the rest; and should the men in charge of the van neglect to empty the receptacles, the omission is at once detected by the register kept at the yard. The collection is carried on during the working hours of the day, and each van makes five journeys three days a week, six journeys two days a week, and three journeys on Saturday. Each load averages about 9 cwt., but the van is capable of holding a ton. The total cost during the year 1874 of collecting and manufacturing the refuse and excreta of 7287 houses, with 3980 closets, amounted to 5284*l.* 3*s.* 7*d.* The refuse of the 43,500 persons inhabiting these houses amounted to 3156 tons of excreta and 5195 tons of ashes; 3497 tons of manure were made from this, which, valued at 4449*l.* 11*s.* 2*d.*, leaves 834*l.* 12*s.* 5*d.* as the net cost of carrying out the new system.

After examining a few of the closets in different parts of the town, we paid a visit to the depôt, accompanied by Mr. Hewson, the borough surveyor, and Mr. Haresceugh, the Manager. It is a large open yard, well away from any dwellings, and not far from the centre of the town.

The following is the process of manufacturing the excreta and dry refuse into manure:

The house refuse, after being thoroughly dried, is passed through a sieve worked by steam power. The fine ash is removed to one of the sheds and banked up, and the cinders are placed on one side, for the use in the furnaces, in which also is burnt the vegetable refuse. Trenches are made in the bank of dry ash, into which are emptied the night-soil or excreta from the tubs; a thin layer of fine ash is then sprinkled over the liquid, and sulphuric acid is added to cause the evaporation of the water and fix the ammonia. The proportion of night-soil and ashes thus treated is about equal. Several trenches are dug and filled with the excreta, which is allowed to soak in for seven days; it is then sufficiently dry to be turned over, and fresh trenches are formed in the ash that composed the banks to the first heap, more night-soil is added, and soaks for another seven days. This process is repeated four times, and after being turned over, is allowed to remain undisturbed for another seven days, by which time the mass has become a powdery manure, capable of being put into bags for sending away. In this manner 80 cwt. of night-soil is mixed with 1 ton of fine ash, and sulphuric acid is added in the proportion of 25 lbs. to 1 ton of excreta. The whole process is very dirty and offensive from beginning to end, more especially when the acid is added. The sheds where the open trenches are undergoing the soaking were almost unbearable at the time of our visit. Air-shafts, worked by a steam fan, were in course of construction for removing the air from the sheds six times during the day, and also to assist in drying the manure; but we very much doubt whether this will prevent the great nuisance now existing. The tubs and vans are all washed out with a hose, three men are constantly washing, and each tub, before being again sent out, has about a quarter of a pint of chloralum solution placed in it.

From the large accumulation of manure in the yard there does not appear to be a ready sale for it. Of 3497 tons made last year, only 1543 tons were sold. The price of the manure is 35s. per ton; and two agents have lately been appointed to try and get rid of the surplus stock.

The amount being manufactured at the present time is at the rate of 71 tons weekly.

Mr. Alderman Taylor, who has patented the system, maintains that the cost of manufacture is less than at Manchester, and

contains a far higher percentage of ammonia and fertilizing properties.

The sewers discharge by several outfalls into the river Roch, as it runs through the town. The large deposit, which takes place at each outfall, has to be periodically removed; but there is no system of purification at present in use. An intercepting sewer is now being made, to carry the sewage lower down the river away from the town; but the Council have not yet decided whether to dispose of it by irrigation or downward intermittent filtration.

Mr. Hewson stated that the Town Council would at once adopt irrigation, if they could get land at a rental of 10*l.* per acre per annum; they have already offered 15*l.*, and been refused. As far as we could learn, there is no regular system of sewer ventilation, except from openings into the street level with the road; but it is intended to adopt some plan in connection with the new sewerage scheme.

HALIFAX.

February 4.

On Thursday, February 4th, we visited Halifax, and were met by the Borough Surveyor, who accompanied us, to make an inspection of the system now in operation in that borough for the disposal of the sewage and the collection of refuse, &c.

The town contains a population of about 70,000, occupying 15,000 houses, and using 9000 privies or thereabouts. The old midden system has been superseded by what is known as the "Goux closet," and the collection from these closets is carried on by the Sanitary Improvement and Manure Manufacturing Company, Limited. The system has been in operation about three and a half years, and is applied to about 2000 houses. The arrangement of the closet is similar to the Rochdale or separate system, there being two receptacles, one for the excreta and another for ashes and refuse.

The receptacle for the excrement before being sent out is lined round the sides and bottom with an absorbent material. The mode of putting it in is by placing a mould inside, leaving a space of about 4 inches between the mould and outside of the receptacle. This space is filled in with the absorbing materials, which appeared to be composed of dry street or shop sweepings and factory waste, to which is added a percentage of sulphate of lime; this is pressed down, and the mould is left in until the receptacle is placed in the closet ready for use, the result being that the absorbing materials

are not disturbed by any movement of the receptacle. The advantage claimed for this plan is that the absorbing medium takes up the urine, prevents fermentation, and greatly reduces the nuisance of manipulating the contents of the receptacles when brought to the depôt. The company attach much importance to this arrangement, and have patented the process. At the depôt it undergoes a process of manufacture by being mixed with several other material products. The ashes with this system do not become part of the manure. There was an unpleasant smell at the yard, but not enough to amount to a nuisance; the yard is not surrounded by residential property, and being 3 miles from the centre of the town, could only be a nuisance to those working in it. It bears favourable comparison on this ground to Manchester and Rochdale. The manure so prepared does not appear to meet with a ready sale, the stores, when we were there, being full.

When the Goux closet was first applied to Halifax, the Corporation paid the company by arrangement 7*s.* per closet. That was subsequently increased to 12*s.* per closet; and we were informed when there that the company could not undertake to continue their operations unless the Corporation would make it 24*s.* per closet per annum for the year 1876. Before coming to any decision on this point, they resolved to visit other towns and ascertain whether it would be desirable to continue the Goux system, or to adopt any other plan.

The mode of collecting is similar to that of Rochdale, the town being divided into districts, with the privies in each district numbered; and the collecting van is constructed in the same way as at Rochdale and Manchester. They require emptying once in fourteen days.

The cost of constructing a closet on this plan is 5*l.*, which is defrayed by the owner. These closets have in all cases been erected by permission.

The sale of manure does not pay the cost of collection. We did not see the Company's Manager, and therefore could not obtain the amount of the net loss; but, judging from the fact that the company cannot continue their works unless the Corporation are willing to pay 24*s.* per closet instead of 12*s.*, we are inclined to think the loss is something considerable.

The old middens are emptied by the Corporation in the night-time, and a charge is made upon the owners at the following rates, which are payable in advance, viz.:

For houses not exceeding 10*l.* rental, 2*s.* 6*d.* per annum. For houses exceeding 10*l.* and under 20*l.*, 4*s.* per annum. For houses exceeding 20*l.* and under 30*l.*, 6*s.* per annum. For houses exceeding 30*l.* and under 40*l.*, 10*s.* per annum. Hotels, beerhouses, warehouses, and workshops, over 40*l.* rental, are charged according to special arrangements. If owners of property fail to pay in advance, the charge is then as follows:

For removing the contents of middens, where the same can be loaded direct into a cart, 1*s.* 4*d.* per cube yard. Where it cannot be so loaded, 2*s.* per cube yard. The whole of the sewage of the borough of Halifax is concentrated to one outlet, and emptied into the river; but before being finally discharged it passes through subsiding tanks, the heavier part of the solid matter in suspension settles, and the effluent sewage goes into the river. The plan is simple subsidence, without any chemical treatment. The tanks are in duplicate, each being divided into several compartments, by walls carried across transversely, with a small opening in the centre of each, made a little lower than the top level of the tank, to allow the sewage to pass from one to the other. This arrangement checks the current of the sewage, and brings it for a time into a comparatively stagnant condition, during which time the subsidence of the more solid part takes place; when one tank is full the sewage is diverted to the other. The tank from which the sewage has been diverted is cleaned out, and the sewage sludge is given to farmers for the carting. The solid matter entering the sewers is considerably reduced by the improved closets. We were not able to form an opinion as to whether the sewage being discharged into the river was a nuisance; and it appeared to us to be difficult to tell whether or not the sewage of Halifax really did increase the pollution of the Hebble, as the whole river, so far as we could see of it, was polluted to such an extent by receiving the drainage from manufactories, that it made it impossible for anyone to say to what extent the sewage increased the evil. We did not find any objectionable smell at the time of our visit.

The sewers are ventilated by Mr. Stott's system, which he has lately arranged and patented. It consists of connecting the street sewer with the furnace of a boiler, in a suitable situation near to the sewer. The connection is made by carrying sewer pipes, proportionate in size to the capacity of the sewer, to the face of the furnace, and connecting them to an air-tight chamber, made of sheet iron, which entirely closes the lower half of the boiler tube below the furnace door. This completely shuts off the furnace from

drawing upon the outer air for combustion, it follows consequently, that the air required for the furnace must be drawn from the sewers: the result is, that as the air thus taken from the sewers passes through the furnace the deleterious gases are burnt.

NOTTINGHAM.

We continued our inquiries at Nottingham on the 5th instant, where we were met by the Medical Officer and Borough Engineer; and, after an interview with them, we inspected, in company with the chief Sanitary Inspector, the system of refuse removal and sewage disposal in that borough.

The population of the municipal borough is 90,000, occupying 19,000 houses; but the entire population of the district, including the suburbs and surrounding district, which forms part of the town, is about 150,000.

Their sanitary operations are almost entirely confined to the borough.

The old midden system has been partly superseded by the improved privies, and what is known as the pail system. The improved privy consists principally of having a circular-shaped ashpit, properly constructed in cement, and made impervious, with the roof carried over it so as to prevent any superfluous water getting in. This is to prevent fermentation and keep the contents dry; at the same time ample means are provided for ventilation. They are considered to be a great improvement on the old ill-appointed middens. The pail closet consists simply of a movable tub, 19 inches in diameter and 17 inches deep; this is placed under the seat, and receives not only the fœcal matter, but the cinders and vegetable refuse are put in, the seat being made to lift entirely up for the purpose; the riser is also made to slide in a groove, so that it can be easily removed when the tub has to be taken away. When they are built in blocks of three, four, or more, there is an extra tub provided for refuse in a centre compartment, or at the end, according to circumstances. These closets occupy very little space, which is of importance where the area is limited. They require emptying once in five days where there is one to each house, and twice or three times a week, or even daily, where there is only one to four or five houses.

The cost of erecting an improved privy is four pounds (4*l.*), an old privy can be converted into a pail closet for two pounds

(2*l.*), and an entire new pail closet can be built for three pounds (3*l.*), which is defrayed by the owner. The receptacles, which cost 3*s.* 9*d.* each to make, are provided by the Corporation, without charge to the owners. The Corporation have power by their Acts to order these closets to be erected where they may deem it necessary, and in default of the owner not complying with their requirements they can proceed to the erection of the closets, and recover the cost; or they can proceed for penalties, from time to time, until the required work is done.

The night-soil collected at Nottingham does not undergo any process of manufacture; it is brought to a place called the wharf, in a thickly-populated part of the town, and unloaded direct into barges, and sold at the rate of 1*s.* 6*d.* a ton, or 2*s.* 10*d.* a ton delivered by truck. The collecting vans are not made the same as at Rochdale and Manchester; there are no closed compartments for the receptacles, they are simply put on the dray with a tightly fitting lid, and covered with a tarpaulin. To facilitate the collection the borough is divided into districts, containing 750 registered blocks, with from two to fourteen closets in each block, each closet having a number attached.

There are now 2793 of these closets in use, accommodating 5019 houses, and used by 25,000 inhabitants. The staff required for emptying them consists of fourteen men and seven horses, each horse costing about 1*l.* and the men's wages about 25*l.* per week; in round numbers, the expense of emptying each closet is 1*d.* per week, or 4*s.* 2*d.* per year. In summer time, when ashes are scarce, the street sweepings are saved and mixed with a disinfecting powder, manufactured at the wharf, by mixing the carbolic acid of commerce with unslaked lime; the bottom of each tub is lined with this before sent out, the object of it being to act as an absorbent, and to neutralize rather than to disinfect the excrement received into it. In places where infectious disease exists the Sanitary Inspector mixes chloride of lime with the contents of the tubs before being carted away to the wharf.

The emptying of the old middens is carried on during the night, with a staff of forty-four men and thirty-four carts, a separate cart being used for domestic refuse. The night-soil on arrival at the yard is at once emptied into barges, and sent off by canal; the garbage, offal, and refuse from slaughter-houses is removed by the Corporation in tubs, within twelve hours of slaughtering, the blood being disposed of by the butchers.

General Scott has lately been experimenting on the urine from public urinals, by filtering upwards through a tank of lime, phosphate of magnesia being formed by the decomposition of urine and carbonate of magnesia, but nothing definite is yet known of the results.

The sewage of Nottingham is now disposed of by being discharged direct into the river Trent; for the last fifteen years great complaints have been made of the offensive condition of the outfall, and the Nottingham canal, which has, with the river Leen, intercepted all the sewage of the town. The Leen valley intercepting sewer is now in course of construction, which will carry the sewage farther from the town, but the Corporation have not decided whether to purify it by irrigation or downward intermittent filtration.

The whole borough is well sewered, and the drains and sewers are ventilated as at Rochdale.

Conclusion.

Having described the systems of refuse collection and sewage disposal in the various towns we have visited, we now propose briefly to lay before you the opinion we have formed on these important subjects.

During our visit we have seen nothing to alter an opinion, long formed, that a systematic plan for removing the refuse undertaken by the Corporation, and a system of sewerage in connection with an intercepting sewer, are necessary for Ipswich. Although not prepared to recommend the system adopted in any one town, we are convinced they are all right in principle, viz. in constructing small closets and receptacles, which necessitate the early removal of excrement and refuse before putrefactive fermentation sets in. We noticed that each town, with the exception of Halifax, was anxious to place before us its own system in the most favourable light, but after a careful and impartial examination we have come to the conclusion that the combined experience of all these towns may be used with advantage in applying a system to Ipswich, and that by selecting the good points from one, rejecting the objectionable ones from another, and having a due regard to the position and character of our own borough, a perfect scheme might be gradually carried out in the town without much difficulty. For instance the manufacturing process carried on at Manchester seemed superior to any of the others, a proof of which is that the Salford Corporation are about to adopt it, but on the other hand it appeared to us that the "Morrell's closet" in operation at Salford

was the more suitable for Ipswich, in spite of the mechanical complication complained of in Manchester.

The manure produced at Rochdale is unquestionably of more value as a fertilizer than any of the others, but the whole process of collection and manufacture is so offensive that, however suitable it may be for a Lancashire or Yorkshire town, it would never be tolerated in a place like Ipswich. At the same time we feel bound to give to Rochdale the credit for being the first town to abolish the wet open middens, and substitute a plan of early and frequent removal of refuse, which has formed the basis on which all the old towns have modelled their improved systems.

The facilities of collection would not be so great in Ipswich as the towns we have visited, as by referring to the plans of the Manchester closet, it will be seen that they nearly all abut on a back passage with yards on both sides, and it is a very rare thing for a receptacle to be carried through a house to be emptied. In Ipswich the number without backways would be considerable, and the time occupied for a given staff in collecting say for a thousand houses would be much more than it would in either of the towns referred to in this Report. The cost of converting and building improved closets in these towns appeared to be somewhat understated, for instance, in the case of Rochdale the cost of converting an old midden into an improved closet is 2*l.* 10*s.*, and for an entire new one 5*l.*, but upon putting the question the Surveyor admitted that it would cost 6*l.* to erect a new one according to their specification.

In Lancashire and Yorkshire stone flags are so abundant and cheap that they are largely used for paving and roofing over the closets, but in Ipswich the roof would have to be constructed of timber and slates, which would raise the estimate for an entire new one to 6*l.* 10*s.* or 7*l.*, exclusive of receptacles.

All the towns where the improved systems are at work are under local Acts, giving them powers to remove all refuse and compel all owners to substitute the new closet for old and dilapidated privies and middens that have been condemned by the sanitary authority.

Before any such system could be established in Ipswich, it would be necessary to obtain a local Act, not only giving powers to compel owners of old houses and builders of new to adopt the closet selected, but also giving the Corporation an absolute right to collect the refuse from every part of the borough.

With regard to the sewerage, all the towns we visited were per-

fectly sewered and drained, and although each differed somewhat in the method of ventilating the sewers, all were unanimous that a perfect system of ventilation was of the greatest importance.

From what we saw and heard we are more than ever convinced that to ventilate a sewer by means of openings level with the street or road, either with or without charcoal trays or traps, is a highly dangerous practice, and ought to be unhesitatingly condemned, and we are of opinion that the best and safest plan to adopt is to construct ventilating shafts at regular intervals and carry them up to such a height that the gases may become diffused in the upper strata of the air. Most of the towns referred to in this Report are still pouring their sewage into small rivers and canals running through them, but nearly all are constructing or about to construct works to intercept the sewage and carry it farther from their midst, but from the small size of the inland rivers and the high price of land they are still undecided how to dispose of it.

We could but notice how favourably Ipswich is situated compared to these inland towns, for what appears to be almost an insurmountable difficulty in their case is very slight in our own, and we feel bound to believe that if the sewage of Ipswich be taken one or two miles down the river and treated by some simple and economical process, such as precipitation by lime before discharging into an arm of the sea, like the Orwell, there will not be anything like the pollution of that beautiful river that is now daily taking place.

There can be no question but that something must be done before long to relieve the town, and we firmly believe that the time has now arrived when by adopting two separate systems of drainage and collection of refuse, the gain to the health, prosperity, and comfort of the people of Ipswich will more than repay the outlay.

We are, Gentlemen,

Your obedient servants,

EDWARD BUCKHAM, Borough Surveyor.
G. S. ELLISTON, Medical Officer of Health.

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No. ... supplie... compens...	2... the ...rior ...tor	22 Have you any difficulty in effectually preventing pollution by sewage?	23 The number of water-closets supplied with water?	24 The number of private baths supplied with water?	25 Remarks on the foregoing questions.
26	N	No.	About 260	25	The reason that we have so few water-closets is that we have no regular system of drainage.
	...assi ...eej ...e si ...pu	Pollution by sewage very inconsiderable.	2,000		
	...N.	None.	About 1,600		
	...o.	No.	Cannot tell.		I shall be better prepared to answer next year.
	...o.	No.	300	150	
	...s much ...ed by ...st.	Yes.	59	8	
	...o.	No.			
	...o.	No.	No limit.	One for every house requiring it.	We strictly watch against waste.
			About 1,000	About 100	
	...er loses ...° of ...ess.	No.	No account kept.	No charge for domestic baths.	The COLD waters of Bath are about 22 degrees of hardness; nearly all the springs issue from the Upper Lias Sand; above which is the inferior Oolite, the Fullers' earth, and the great Oolite or Bath stone. Springs from the Fullers' earth not permanent.
By ... Board... our ...		No.	About 20	About 20 and 1 public bath.	We are one of three partners, viz. Dewsbury, Batley, and Heckmondwike. The answers given are our proportion, viz. two-sixths of the whole. New works proposed to be constructed at an estimated cost 200,000*l*.

JOHN WRAY, C.E., Surveyor.	to supply a population of 8,000, at 25 gallons per head per day.	Ballydoolagh Lough.	At present about 100,000	...
Farnham. WILLIAM WELLS.	210 houses; 4 breweries.	Springs.	In summer 30,000	...00, ...
Filey, Yorkshire. DAVISON PHILLISKIRK, Sec., Water Works.	1,800	Drainage of land, and from chalk-stone rock.	50,000 If required.	...